ne magazine of aerospace technologies / DEC. 1959

space aeronautics

formerly Aviation Age

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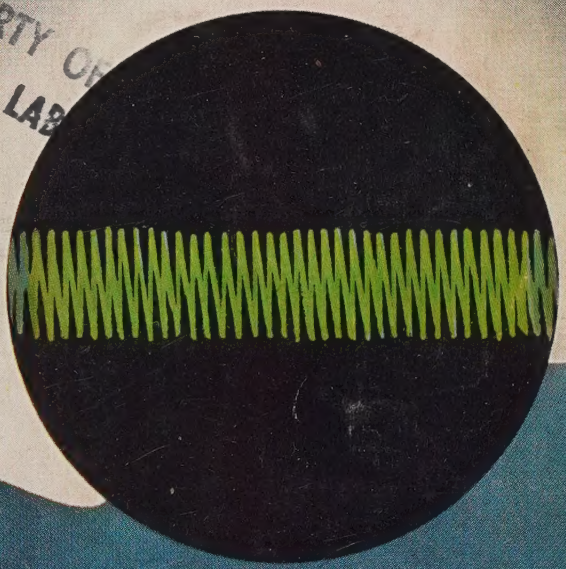
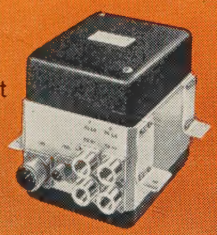


propulsion...

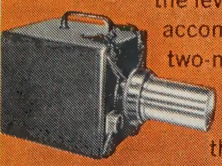
state of the art

Weimer Purcell

ADVANCED FUEL MANAGEMENT ...FROM SMI



The requirements of accurately tanking missiles with propellants is but one of the areas of fuel management in which Servomechanisms, Inc. has demonstrated capability. *Propellant utilization* and *thrust control* are other areas in which SMI has developed highly accurate and precise measuring and control systems.



SMI's LOX Tanking Computer, which has been in production for the past year, accurately measures, controls and indicates the level of liquid oxygen in missile tanks. Loading is accomplished rapidly and accurately due to a unique two-mode control system. The first mode permits extremely high pumping rates until about 98% capacity is reached. The second mode then takes over and controls a precise proportioning valve which adds the necessary LOX to fill the tank within 0.1% accuracy. The second mode also provides continuous topping, thus compensating for LOX evaporation losses during standby.

SMI has currently in development, more advanced fuel management systems to meet the increasingly complex requirements of the next generation of missiles and spacecraft.

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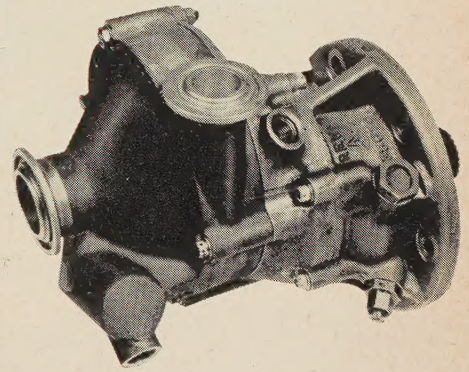
The products of SMI are available in Canada and throughout the world through Servomechanisms (Canada) Limited, Toronto 15, Ontar

SUNDYNE water injection pump built to operate 1500 hours between overhaul



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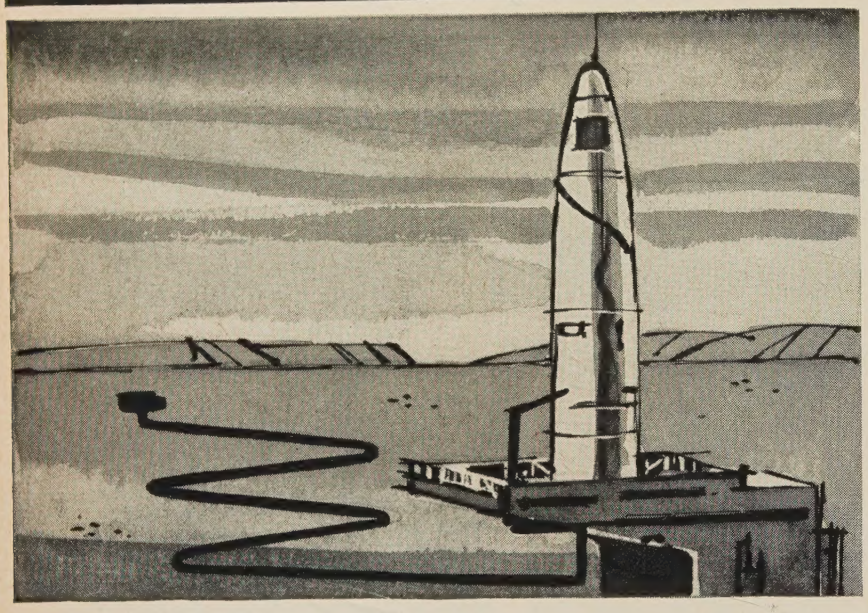
project:
FUELING THE THOR—FASTER



FRI develops successful automated hookup and couplings for fast LOX and fuel transfer

Here, the problem was 5-fold. (1) Develop a flexible coupling for automated hookup. (2) Prevent leakage. (3) Protect vital internal parts from icing. (4) Provide high flow with minimum pressure drop. (5) Keep weight to a minimum.

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space/aeronautics

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Reaching for the Moon, Mr Designer?

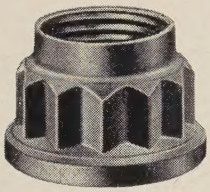
Here's a tip... Millions of Kaylock® nuts ago, a new aircraft fastener made its bow... the Kaylock H20, first lightweight, high tensile, all-metal, self-locking nut.

Its significant improvement over then-existing fasteners – lighter weight, greater strength, smaller envelope – won immediate acceptance by airframe weight engineers and designers.

Today, with a premium on weight and space savings in aero-space vehicles and engines, design engineers depend more than ever on Kaylock nuts. So here's a tip...

If you're reaching for the moon, Mr. Designer, reach for your up-to-the-minute Kaylock catalogs first. Chances are, *your* "brainchild" will *get there sooner.*

Fastener with a past – that's the Kaylock H20. A favorite callout of design engineers for the past 3 years, the H20 was the first high tensile, all-metal nut using the elliptical self-locking principle for which Kaylock nuts are famous. "Vital statistics" include:

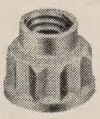


Service Temperature: 550°F
Tensile Strength: 180,000PSI
Material: Alloy Steel

Ready to Help – Here are a few of the Kaylock external wrenching nuts built to meet rigid requirements in weight and space reduction.

H14 — Service Temperature: 550°F, Tensile Strength: 160,000PSI, Material: Carbon Steel

H23 — Service Temperature: 550°F, Tensile Strength: 180,000PSI, Material: Alloy Steel

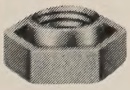


H24 — Service Temperature: 550°F, Tensile Strength: 220,000PSI, Material: Alloy Steel

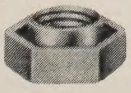
H41 — Service Temperature: 900°F, Tensile Strength: 125,000PSI, Material: A286 CRES

H33 — Service Temperature: 1200°F, Tensile Strength: 160,000PSI, Material: A286 CRES

H19083 — Service Temperature: 1400°F, Tensile Strength: 160,000PSI, Material: M252 CRES



H10 — Service Temperature: 550°F, Tensile Strength: 125,000PSI, Material: Carbon Steel



H31 — Service Temperature: 900°F, Tensile Strength: 125,000PSI, Material: A286 CRES

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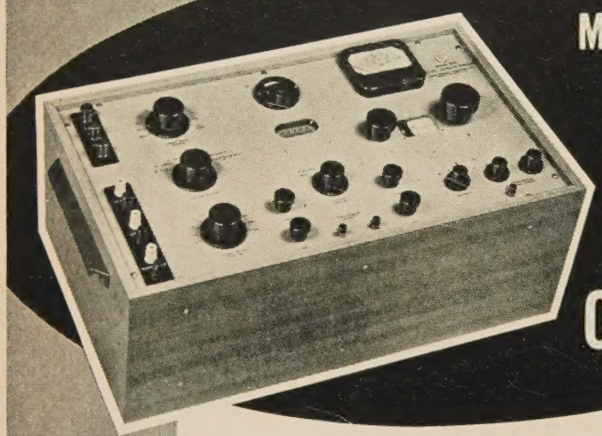

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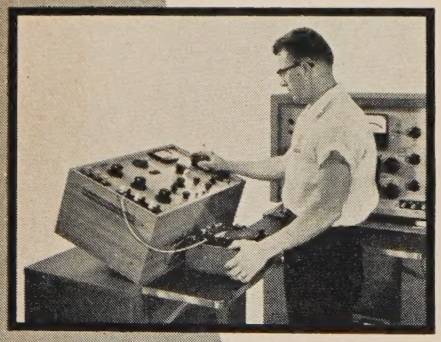
The Model 1605 AC-DC Calibration/Transfer Standard is a multi-function instrument capable of measuring AC and DC voltage and current up to 1500 volts and 15 amperes. It includes a precision four-digit readout potentiometer, laboratory standard cell, precision voltage multipliers, precision shunts hermetically sealed in oil, light beam galvanometer, AC monitoring meter, thermal converter and all necessary batteries and controls. DC measurements utilize the potentiometer or the potentiometer in conjunction with the voltage multipliers or shunts. For AC measurements the potentiometer and/or multiplier-shunt arrangement is used with the compensated AC-DC transfer element.



LIMIT OF ERROR

DC: 0.05% with correction factors; 0.1% direct reading.

AC: 0.065% with correction factors; 0.13% direct reading.
(AC accuracies are to 50 kc on most ranges.)

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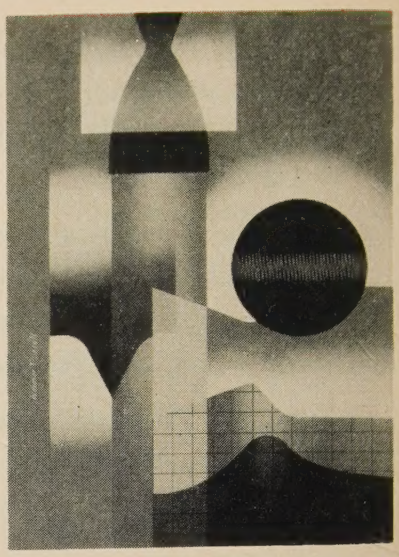
cover story



Efficient nozzle design, stable combustion, and good heat transfer characteristics are the highlights of chemical rocket development brought together by Weimer Pursell, this month's cover artist. Both conventional nozzles and the novel, spike-shaped "plug" nozzle are shown. The stylized curve at the lower right presents an actual heat transfer profile, while the oscilloscope trace symbolizes combustion stability. The occasion for this cover is Contributing Editor Kurt Stehling's special review of the state of the art in chemical propulsion (*page 42*). This article, accesses the future of chemical rockets in terms of the space missions planned for the next two decades and reviews the technical problems that must be overcome if we are to get more performance out of chemical rockets.

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The Navy's new versatile Vigilante

Roaming the oceans of the world aboard its carrier, the A3J Vigilante will fill an important dual role for the Navy. It can pinpoint its target in a brushfire incident... or pulverize it in an all-out conflict.

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Besides versatility, speed, range, accuracy, the Vigilante also carries with it the human judgment of its crew—two highly trained Navy men who can report results, react to emergencies, and be redirected or recalled. Men who will make the Vigilante doubly dangerous in its dual role.

THE COLUMBUS DIVISION OF NORTH AMERICAN AVIATION, INC.

Columbus, Ohio

December 1959

space aeronautics

volume 32, number 6

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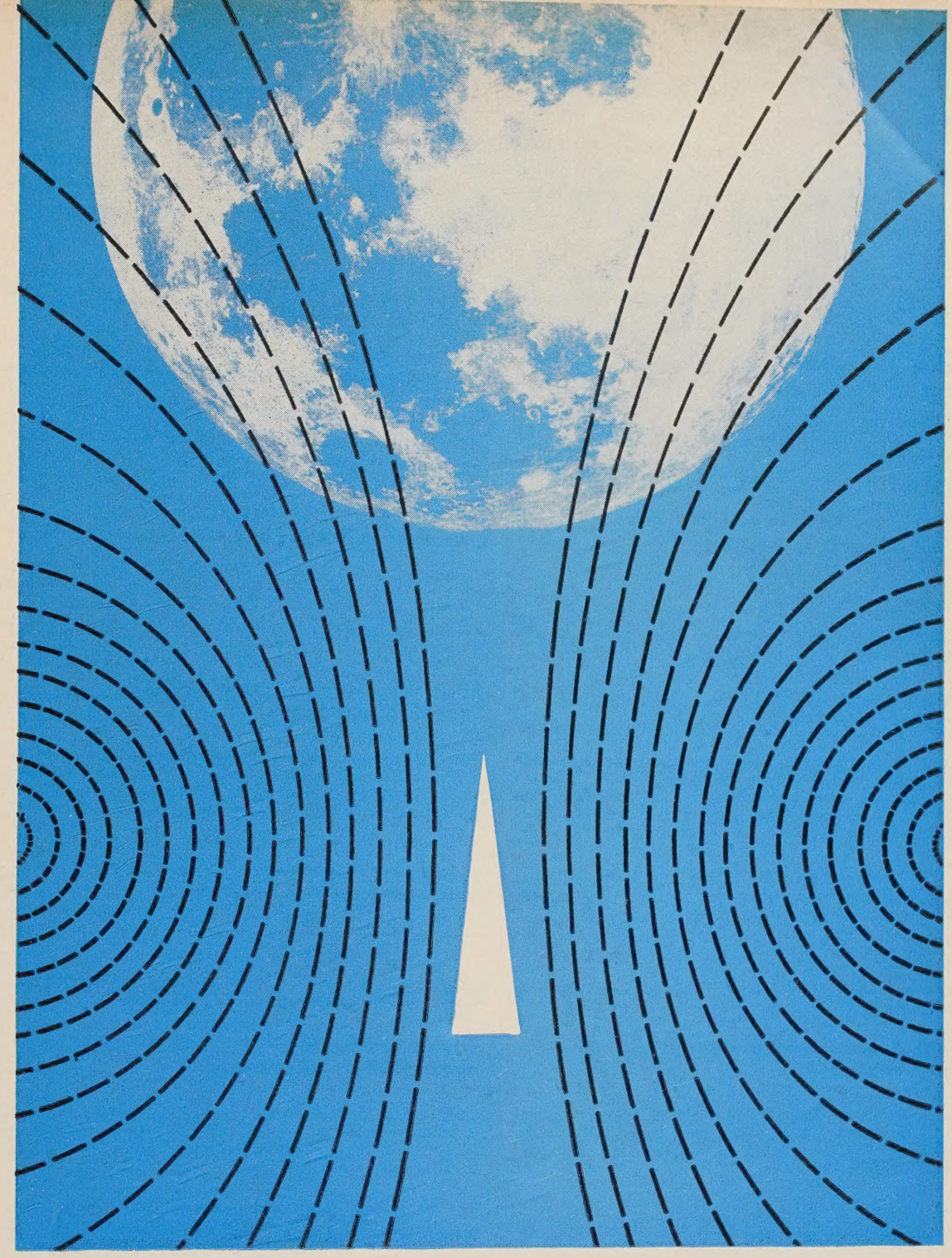

Avco's magnetic spaceflight—

When man first travels beyond the moon, the thrust may well be supplied by a new system of propulsion, based on principles of magnetohydrodynamics (MHD). This system uses a magnetic field to speed and expel ionized gas for power output. Magnetic thrust propulsion is a current project of the Avco-Everett Research Laboratory . . . working to extend the knowledge of man.

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in this issue

Here's a quick rundown of the technical information offered in the articles in this issue. You can also use these article abstracts to build up your own permanent record for reference in the future—just clip them, paste them up on standard three-by-five cards, and file them.

Aerospace Engineering
Propulsion

Astia code: 27-3
Your code:

Chemical propulsion: state of the art

Review of current status of advanced chemical rocket propulsion design. Past progress is assessed and future progress extrapolated. Outstanding current design problems for both liquid and solid rockets are discussed in detail.

by Kurt R. Stehling, Contributing Technical Editor

space/aeronautics 32/6 (Dec. '59) p. 42

Aerospace Engineering
Propulsion

Astia code: 27-2
Your code:

Orpheus turbojet features reliability, light weight (Design Progress)

Design details of Bristol Siddeley Orpheus Mk 803 jet engine include two-bearing layout, air intake casing assembly, flame tube, compressor and front bearing seals, compressor half-casing, and engine ventilation systems.

by Randolph Hawthorne, Editor

space/aeronautics 32/6 (Dec. '59) p. 59

Aerospace Engineering
Accessory Components

Astia code: 7-5
Your code:

Designing a generator for 600-deg F operation

Brief survey of high reliability generator configurations and their limitations. A generator selected for a 600-deg F development program is described, and its characteristics are related to conventional designs. Diagrams and photos show the final inductor-lundell design.

by J. T. Bateman, General Electric Co.

space/aeronautics 32/6 (Dec. '59) p. 47

Aerospace Engineering
Testing

Astia code: 30-5
Your code:

Atlas reliability program yields improved components

Detailed analysis of the reliability program for the Atlas ICBM. Attention is focused on the differences between the Atlas program and other aerospace reliability programs. Sample results are presented.

by C. C. Campbell, Convair

space/aeronautics 32/6 (Dec. '59) p. 65

Aerospace Engineering
Systems Engineering

Astia code: 12-1, -4
Your code:

Boeing stresses maneuverability in Bomarc evolution

Design study of Boeing Bomarc IM-99 pilotless interceptor. Evolution of missile from early Gapa test vehicle is discussed. Design features of current "A" and "B" versions are described.

by Irwin Stambler, Associate Editor

space/aeronautics 32/6 (Dec. '59) p. 50

Aerospace Engineering
Materials, Production Engineering

Astia code: 17-2, -4; 26-1
Your code:

Titanium provides notch-ductile rocket cases

Comparison of 6Al-4V, 2.5Al-16V and 13V-11Cr-3Al titanium alloys, with high strength steels for use in rocket cases. Five methods of fabrications for the three titanium alloys are described.

by A. N. Eshman, Mallory-Sharon Metals

space/aeronautics 32/6 (Dec. '59) p. 73

Aerospace Engineering
Ground Support

Astia code: 12-3
Your code:

Sergeant GSE sets pattern for IRBM mobility

Analysis of complete ground support equipment for Army's Sergeant ballistic missile. Detail diagrams, pictures and description of special design features (erector-launcher, azimuth orientation system, etc.). Operation of equipment and essentials of automatic checkout system design are discussed.

by Victor de Biasi, Associate Editor

space/aeronautics 32/6 (Dec. '59) p. 54

Aerospace Engineering
Accessory Systems

Astia code: 1-2
Your code:

Anti-icing for a turboprop transport

Review of the design theory and physical configuration of the Lockheed Electra ice protection system using bleed air from turboprop compressor. Heat balance equations are shown, and the calculation of system requirements on a high speed computer is explained.

by B. L. Messinger & J. B. Werner, Lockheed Aircraft

space/aeronautics 32/6 (Dec. '59) p. 81

To make filing easier, each abstract is coded according to the Astia Distribution Guide. Copies of this guide are available from Armed Services Technical Information Agency, Arlington Hall Sta., Arlington 12, Va. There is also room on the abstracts for you to insert your own key if you use a special coding system.

Aerospace Engineering
Testing, Accessory Components

Astia code: 1-1; 30-3
Your code:

"Light foot quantizer" for highly precise time measurement

Discussion of new instrumentation device and measuring technique for resolving time information to levels several orders of magnitude better than those provided by earlier equipment. Installation of this system on rocket sled track is described.

by M. A. Alexander & Douglas Epps, Computer Equipment

space/aeronautics 32/6 (Dec. '59) p. 101

Aerospace Engineering
Materials

Astia code: 14-8
Your code:

Fluorocarbon studies lead to high temperature polymers

Review of NBS work on the development of high temperature, radiation-resistant fluoroaromatic polymers. Some progress has been made in the synthesis of starting materials and intermediates for conversion to suitable polymers.

by Irwin Stambler, Associate Editor

space/aeronautics 32/6 (Dec. '59) p. 109

Aerospace Electronics

Astia code: 5-2
Your code:

Designing for space communications

Properties of moon as passive radio relay, problems of passive satellite communications, three types of active communications satellites, and communications to space via a space vehicle are discussed. Curves are given for communications system parameters.

by Joseph Vogelman, Capehart

space/aeronautics 32/6 (Dec. '59) p. 176

Aerospace Electronics

Astia code: 8-2, -3
Your code:

Ferrite phase shifter paves way for inertialess scanning radar

Axial-field ferrite phase shifter is discussed, particularly with regard to its use in electronically scanned radar antennas, and compared with the older transverse-field type. Design details are reviewed.

by F. E. Goodwin & T. A. Nussmeier, Hughes Aircraft

space/aeronautics 32/6 (Dec. '59) p. 131

Aerospace Electronics

Astia code: 6-3; 8-2
Your code:

IR cell cooler extends detection ranges (Design Digest)

Design analysis of a miniature IR cooler that improves on the standard types of coolers operating on the Joule-Thomson gas-expansion principle. The mechanics and thermodynamics of the closed-cycle device are fully described and illustrated.

by Bernard Kovit, Associate Electronics Editor

space/aeronautics 32/6 (Dec. '59) p. 137

Aerospace Electronics

Astia code: 19-3
Your code:

Target-plus-symbol display simplifies ATC radar tracking

Analysis of a radar track-while-scan system for displays of televised symbolic information near targets on a PPI display. Intensity modulation of PPI scope with symbol video from a closed-circuit TV subsystem is detailed.

by Abe Shulman & Marvin Bernstein, Airborne Instruments Laboratory

space/aeronautics 32/6 (Dec. '59) p. 141

Aerospace Electronics

Astia code: 7-5; 8-2, -3
Your code:

Finding the optimum load for solar cells

A simple graphical method of determining optimum load resistance from the dark diode curve. Use of this method for optimizing the load under constant and varying illumination intensities is discussed.

by A. J. Heager & T. R. Nisbet, Lockheed Aircraft

space/aeronautics 32/6 (Dec. '59) p. 153

Aerospace Electronics

Astia code: 8-1
Your code:

How to protect radomes from lightning

Procedures and techniques used to develop a lightning protection system for a general-purpose aircraft radome. Studies of relative vulnerability of DC-8 airframe areas, materials and structural factors, and the design of the resulting system are reviewed.

by M. P. Amson, Douglas Aircraft

space/aeronautics 32/6 (Dec. '59) p. 177

BENDIX RED BANK ANNOUNCES NEW FACILITIES for research, development and production in Safing, Arming, and Fuzing Systems and Components. As systems increase in complexity the need for higher precision in safing, arming, and fuzing grows. To meet this need, Bendix Red Bank Division has created a new department exclusively devoted to design, engineering, and production techniques for these vital systems. ■ This "Special Products Department" is staffed by engineers selected for special abilities in this field. Environmental test equipment and precision tooling enable swift, accurate transition from design to product. Fresh approaches to design and production problems are encouraged by environment conducive to creative thinking. Performance-proved production resources back up new ideas. ■ Since 1941, Bendix Red Bank has grown from a maker of simple electrical devices to a producer of complex electrical and electronic systems. This is added assurance that here your most complex safing, arming, and fuzing problems will receive knowledgeable attention from fundamental analysis through final production.

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A FIELD that has never before been covered comprehensively by an aerospace publication will be the subject of a SPACE/AERONAUTICS special report in the January issue: Undersea Weapon Systems. Early this year, SPACE/AERONAUTICS' editors became convinced—after many conversations with engineers in the field and industry leaders—that modern undersea warfare poses design problems that are tailor-made for the capabilities of the aerospace companies. As a result, they decided to put together a detailed and yet compact package of information on this important new field.

The key elements of our special report will be four staff-written state-of-the-art surveys on detection, guidance and navigation, hydrodynamics, and powerplants. In addition, there will be a survey of the role of undersea warfare in our national defense strategy, a report on the use of the systems concept in undersea design, a basic feature discussing the physical characteristics of the undersea environment, and articles dealing with such special developments as hovering craft, hydrofoils, and test tanks.

Probably the most eye-catching feature of the special report will be a special four-color, two-page pull-out map of the North Atlantic, which will be the first map ever published that combines information on the topography of the ocean bottom, currents at various depths, isotherms, and salinity.

WHEN YOU come right down to it, aircraft structures have changed only very slightly in the past. Is this state of affairs going to continue when we get into the Mach 3 range? A detailed answer to this question will be given in a review of the design alternatives among which the designer of trisonic transports can choose.

coming soon

WITH EVERY new design, it becomes more obvious that we will have to rely more and more heavily on stainless steel in our upcoming high performance vehicle. Two important new types of high strength stainless will be reviewed in an article giving previously unreleased data.

IN DISCUSSIONS of free-fall conditions in space flight, there's been a lot of talk about how to feed the crew, some talk about how to keep accessory components working, and virtually no talk about propulsion and control. Yet it's obvious that we won't always be in a position just to let gravity take over. What alternatives do we have? Contributing Editor Kurt Stehling will give you an answer to this puzzling question.

S/A goes underwater

OUR UNDERSEA Weapon Systems special report editors have been getting a salty air about them lately. Starting at the Pentagon in BuShips and Office of Naval Research, the team has spread out over the whole country and Europe.

Everywhere they go, the team is ferreting out what is being done, and what is needed, in undersea warfare systems development. They talk with people on detection, navigation, guidance and control, propulsion, hydrodynamics, and applied oceanography.

Two striking observations our editors have made are: (1) we know less about the oceans than we do about the moon and (2) we are just getting our feet wet so far as underwater detection and communications are concerned.

Most impressive to the editorial team is the dedication most engineers and Naval project officers display in the underseas warfare problems. The Navy men directly involved are deeply concerned with how relatively little we know about those problems, and how far we have to go in countering the threat of the submarine vehicle, whether nuclear powered or conventional.

Unfortunately, our editors found only a small minority are thinking about how we can truly exploit the potential of advanced underwater vehicles and weapons. They have to look to the Navy command to make known the Navy's needs. The top command, in turn, seems to be waiting for the aerospace industry to show what it can do to solve certain problems before these needs can be stated.

One of the purposes of our special report in January is to point up for those in the industry not yet alert to it that there is a big potential for their technical talents which offers business opportunities.

The Navy needs industry's help. The oceans are a new frontier for the aerospace engineer and scientist. The technologies involved are much the same as those used in airborne and space vehicles.

But the problems are quite different in many respects. Take detection and communication, for example. The problems of these two in undersea operations are enough to split the skulls of any group of specialists in those fields.

How do you detect, locate, identify, and track an underwater vehicle, not just thousands of feet away, but hundreds of miles away? The problems vary as to whether it is an underwater-to-underwater condition, or an airborne-to-underwater, or underwater-to-airborne condition.

For propulsion engineers, how can you apply jet propulsion principles to underwater vehicles? The need here is to overcome the cavitation limits of marine propellers, just as Mach number limits of aircraft propellers were bypassed by the use of turbojet or rocket engines.

How do you design vehicles for speeds of several hundred knots underwater? The structural problems, too, of undersea vehicles operating many thousands of feet below the surface might curl the hair of conventional bald-headed naval architects.

Already about $2 billion is being spent in undersea projects. But this is just the start, say some reliable sources.

Look for our January special report. We think it may give you a broad picture of what is involved so that you can judge how your company's capabilities can be put to use, if not already engaged, or where else you may apply them.

Other industry activities of our editors

Kurt Stehling, Contributing Technical Editor, who also is group head in NASA's Rocket Vehicles Division, was made a fellow of the American Rocket Society at the ARS' 14th annual meeting in Washington, D.C., last month.

Jim Holahan, our Electronics Editor, was named chairman of the Professional Group on Aeronautical and Navigational Electronics, a local chapter of the IRE. Jim chaired his first meeting at the ITT auditorium in Nutley, N.J., on November 12.

Associate Editor Irwin Stambler gave a paper before the Magnesium Association meeting in New York on October 20. His subject: "Future Trends in Materials for the Aerospace Industry—What Role for Magnesium?"

Editor Randolph Hawthorne took part in a spirited panel discussion on the merits of the metric system for American industry in Detroit—a stronghold of the English system—on October 22. The *New York Times* reported the encounter as "indecisive". The American Standards Association may stage a return engagement next Spring.

William L. Maas

Publisher

Complex machining was avoided on the T-38 canopy supports with castings of high-strength Ductaluminum.
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DUCTALUMINUM CASTINGS TO MIL-C-21180A SAVE NORTHROP $1,500 PER T-38 JET

Using high-strength Ductaluminum castings for three structural canopy supports on the new T-38 supersonic jet trainer saved Northrop $1,500 per ship. The alternative—a fabricated assembly of hog-outs from forgings and extrusions—would have occupied greater space, weighed nine pounds extra, and cost $1,500 more for each aircraft.

Northrop's example proves that high-strength castings with guaranteed mechanical properties (in the *casting*) can be used in place of forgings, extrusions or weldments for structural parts at considerable savings to the manufacturer. Consider these advantages of castings: lower tooling cost, intricate design, cast-in lightening holes and bosses, and rigid, one-piece construction.

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*Higher properties can be guaranteed in castings with favorable design characteristics.

A-3198

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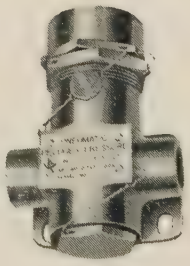

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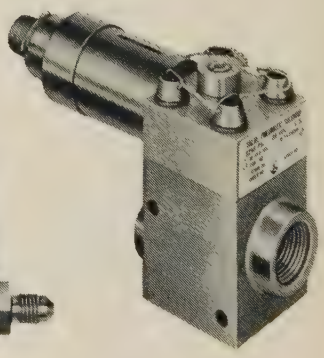

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editorial

"As soon as their guard is down . . ."

WINNING WORDS by Khrushchev have softened the heads of the West's leaders. Both the British and U.S. act as though we already were entering the promised land of friendship and good will with the Soviets. Despite all the talk of being "firm" on Berlin, the lambs are about to lie down with the lion, and they can't wait to cuddle up.

Right at this moment, in Pentagon Room 3E869, our defense budget programs are being cut, "not to the bone, but to the marrow." A $40.4 billion defense budget is in the making for fiscal 1961—more than a billion dollar drop from this year's estimated spending.

Hardest hit will be the Air Force. It is being asked to cut its planned spending by nearly $2 billion. The Navy is making an effort to lop off a billion; the Army $700 million.

Biggest cuts for all services will come in missiles, other "new weapons", in research and development.

Meanwhile, the Soviets shove through their Parliament the largest "peacetime" budget in their history: 744.8 billion rubles as against 711.9 billion previously.

Significantly, funds for "science" are up 15 per cent. This includes space exploration projects as well as missile developments. Spending for "education" will go up eight per cent. Top priority still goes to "heavy industry" production rather than to so-called consumer goods.

THE EISENHOWER Administration appears bent on fulfilling a prophecy made 28 years ago in Moscow. Dimitri Z. Manuilsky, speaking before the Lenin School of Political Warfare in 1931, said:

"War to the hilt between communism and capitalism is inevitable. Today, of course, we are not strong enough to attack. Our time will come in 20 or 30 years. To win, we shall need the element of surprise. So we shall begin by launching the most spectacular peace movement on record. There will be many electrifying overtures and unheard-of concessions.

"The capitalistic countries, stupid and decadent, will rejoice to cooperate in their own destruction. They will leap at another chance to be friends. As soon as their guard is down, we shall smash them with our clenched fist."

Could any plan be more explicit? Are we not reacting as predicted? Isn't it folly to let down our guard because Khrushchev talks "peace"?

Even as with Hitler's "Mein Kampf", we do not believe a word of the Soviets' real plan of subjugation. We choose to listen instead to their words of peace and disarmament.

As Father Divine's followers used to say: "Peace—it is wonderful."

Randolph Hawthorne, Editor

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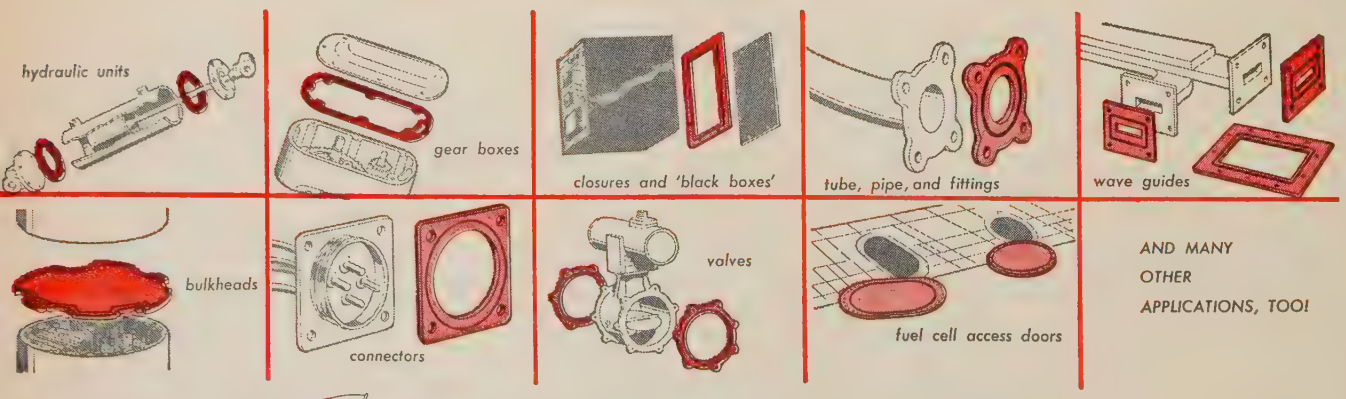

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washington briefing

by **A. N. Wecksler,** Washington Bureau Chief

Pentagon pushing for more subcontracting

COST-CONSCIOUS military services are placing heavy emphasis on what they call the "make or buy" program.

Under the weapon system management concept, industry was given greater leeway in production of major components, assemblies, subassemblies and parts. There were fewer items of government-furnished equipment (GFE).

As the costs of defense systems have increased, however, the General Accounting Office has become more and more critical of the price the Government has had to pay for parts.

The Government Accounting Office took the position that weapon system managements have, in some instances, favored their own facilities for the production of items, even though by making these items, the costs might be higher than if they subcontracted the work.

To meet these criticisms, the Department of Defense is requiring the procurement officers in the services to review contractors' "make or buy" programs and also proposed subcontracts where such decisions will have a substantial impact on price, contract performance, or administration.

Such a review should be made, under the Department of Defense ruling, if (1) the item, system, or work is complex; the dollar value involved is substantial, or competition is restricted, and (2) if cost reimbursement, price redetermination or incentive-type contracts are to be used.

These instructions obviously affect the entire range of military procurement in the aerospace field.

The military procurement officers are instructed to review the "make or buy" program proposed by the contractor during the negotiation of the contract.

Here is what the review is supposed to cover:

- the effect of the contractor's plan to "make or buy" on price, quality, delivery, and performance of the product;
- whether the contractor plans to broaden the number of subcontractors and suppliers by use of competitive bidding;
- whether the contractor has taken into consideration the competence, abilities, experience, and capacities available in other companies;
- whether small business is given a chance to compete for subcontracts;
- whether the contractor or major subcontractors propose to do work in their own plants when the proposed work differs significantly from their normal in-plant operations or they are not historically suited for it;
- whether production of the item or performance of the work will create a requirement for additional plant facilities to be furnished either by the government or by the contractor or subcontractors;
- whether the contractor proposes to use additional Government-furnished facilities to do work when there is capacity elsewhere not involving government facilities that is competitive in quality, delivery, and overall cost.
- other factors, such as the nature of the item, experience of the contractor with similar items, future requirements, engineering, tooling, starting load costs, market conditions, and the availability of personnel and material.

The military contracting officers are instructed to review the program submitted by the prospective contractor in the the light of the foregoing criteria. After agreement on the program is reached, the contracting officer is required to notify the contractor of the Government's approval.

If after approval of the program the contractor wants to change any part of the "make or buy" program, he has to notify the contracting officer in advance.

In addition to a strict surveillance over the contractor's "make or buy" program, the military contracting officer now has standing orders to review subcontracts, making a careful and thorough evaluation if the prices appear to be high, if there is no cost information for the items involved, or if the subcontract is placed on a cost-plus basis.

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industry viewpoint

by **Robert M. Loebelson,** Associate Editor

Industry must provide capability, not capacity

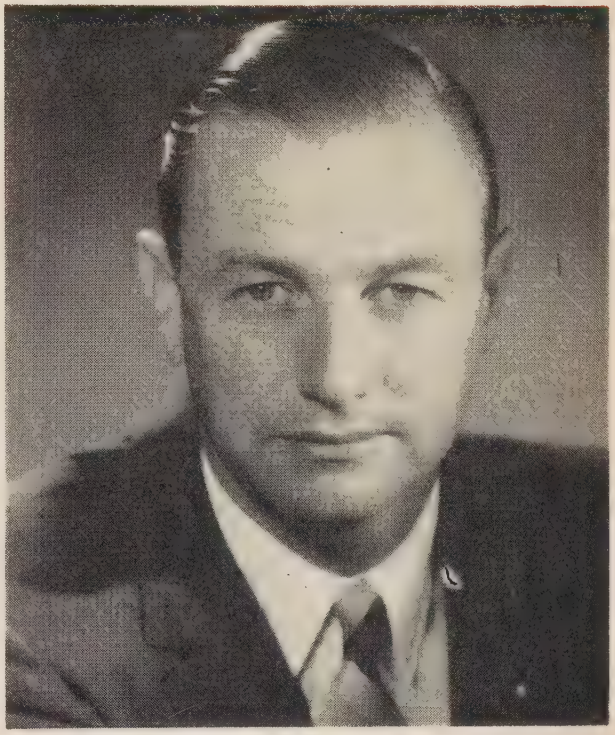
ONE OF the major problems facing Defense Department planners is the abundance of productive capacity and the relative shortage of technological capability throughout the aerospace industry. To T. V. Jones, president of Northrop Corp., there is only one way in which the industry and the companies within it can help solve this dilemma. As he sees it, individual firms must choose their future niche and become extremely competent in their selected areas. "It is only in this way," he declares, "that many present organizations will be able to survive forthcoming procurement shake-outs."

Jones points out that all the military services will be buying fewer weapon systems in the future. He adds that no firm can hope to fulfill all of the requirements for today's complex weapon systems. "All that means," he declares, "is that companies that don't write off marginal sections or divisions will be in trouble."

The Northrop official contends that successful bidding for prime weapon system contracts will demand the highest level of management capability. "Those firms which end up as the prime contractors on the few weapon systems of the future will have a major responsibility to find the most technologically advanced contractors and subcontractors," he says. "These primes will be responsible not only for finding the best subsystem producers but will also have to spell out what each of these subcontractors will have to do."

Jones believes the U.S. can no longer afford the old system of "having a grab bag of weapon systems and choosing the best after prototypes have been built." Companies in the aerospace industry, he insists, should be truly sensitive to future military needs. And, he adds, they must plan far enough ahead to be ready with proposals integrated from preliminary design through production.

Northrop's president asserts that technology in the industry has moved so fast that no company can become dominant in all aerospace fields. "All that means," he declares, "is that a prime manufacturer's number one responsibility and path to success in the future will be his ability to specify and choose the best associate companies on a continuing basis."

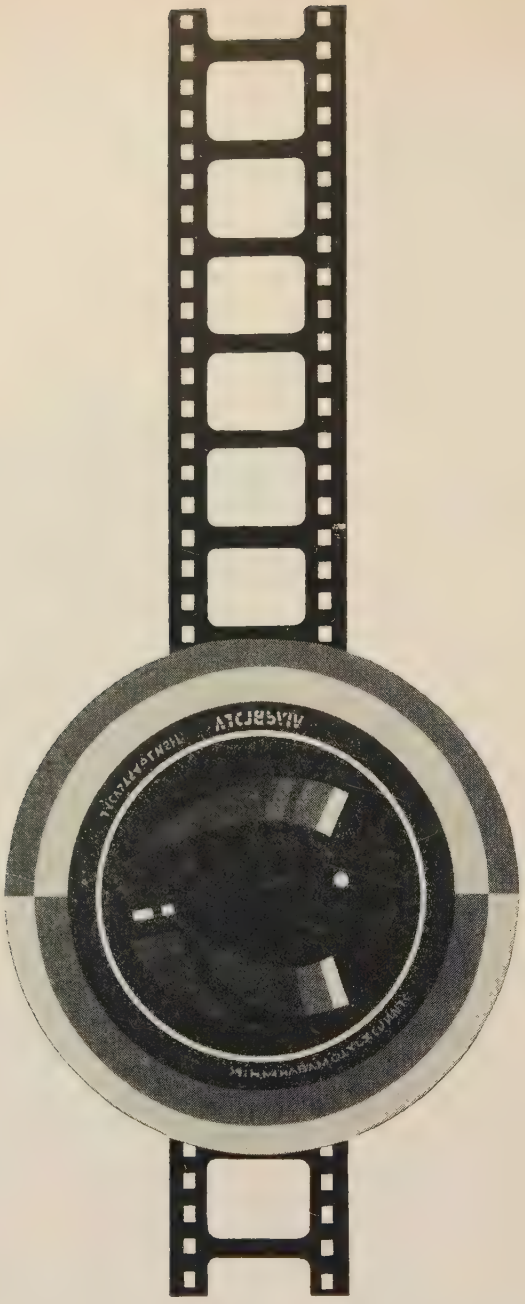


T. V. JONES, president, Northrop Corp.

By contrast, says Jones, in the future some firms that have chosen to become component suppliers may well end up with greater sales and earnings than the so-called "primes".

The fact that change is becoming the norm in the aerospace industry, Jones states, is responsible for the premature gray in the hair of industry executives. "Success in itself can hold the seeds of danger. A company can concentrate so fully on today's successful product that it really doesn't have the time —nor sometimes the inclination—to develop tomorrow's."

Jones believes the only way many industry firms can survive during the next decade or more is to recognize their own capabilities and limitations and decide how they can best fulfill future military requirements.



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Increase in money for materials R&D is predicted

MATERIALS R&D SPENDING by the Department of Defense has gone up from an estimated $70,000,000 in fiscal '59 to $90,000,000 for fiscal '60, SPACE/AERONAUTICS Associate Editor Irwin Stambler told a recent conference of the Magnesium Association. Future spending for basic materials R&D probably will go even higher, he stated.

Stambler also pointed out the increasing need for lighter metals in ground support system. Mobility and air-transportability requirements are making GSE designers pay more attention to weight factor. In the Army's new all-purpose tracked M-113 vehicle, to be used as a missile launcher, troop carrier, etc., just about all of the structure is series 5000 aluminum, Stambler told the conference. The major alloying element of such aluminum materials as 5083 and 5086, is magnesium (used at 4-5 per cent).

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CONTINUING SOVIET progress in the aerospace field has led to new demands that the Administration take concrete actions to close the admitted gap. The transfer of Wernher von Braun and his Redstone Arsenal scientists to NASA is acknowledged as a major step in the right direction (even though it contradicted President Eisenhower's decision against such a switch a year ago). It also will strongly affect Defense Secretary Neil McElroy's September edict in which he turned all military responsibilities over to USAF.

Several Democrats, obviously trying to make political capital out of our lag in the space race, are clamoring for a single individual or group to monitor the national space program. When Congress reconvenes, Ohio's Stephen M. Young will introduce a Senate measure proposing a space science head at the cabinet level. This Secretary of Space and Aeronautical Sciences would be empowered to direct a U. S. space program. A similar proposal, made last year by Sen. Hubert Humphrey (D., Minn.), got nowhere.

Symington: Space experts should plan space program

ANOTHER APPROACH is recommended by Sen. Stuart Symington (D., Mo.) who wants the space program "planned by space experts who understand the challenge, instead of budget experts who do not." According to the Missouri presidential hopeful, "one organization (which might well be comparable to the Manhattan Project of World War II) should be created to run the program. In any case, it must be equipped and able to do the job, and one man of top competence should be placed in charge."

Symington points out that few Americans realize that "the Soviets have sent into space more of a payload in just one of their shots than we have in all our space efforts." He maintains that a single space group with the proper responsibility and authority "would go far toward eliminating the waste of service rivalries, specialized facilities, and taxpayers' money."

Redstone scientists get chance to concentrate on space efforts

THE VON BRAUN TEAM at Huntsville, Ala., appears satisfied with the tie-in with NASA. The Army thinks it will still be able to arrange for certain work at Redstone Arsenal on a contract basis—a reversal of the situation that has existed between NASA and the Army for the past year—but the Huntsville scientists now will be concentrating primarily on space vehicles, especially the 1,500,000-lb-thrust Saturn booster.

Although the Von Braun group has done notable work with the Redstone and Jupiter ballistic missiles for the Army and on the Martin Pershing as well, the primary interest at Redstone has been space exploration. The transfer to NASA will enable the Redstone scientists to concentrate on space—if the funding for the Saturn project is stepped up.

The President, in making the transfer, indicated there would be an increase for the Saturn cluster. Von Braun would like to speed up the program still more.

WHETHER OR NOT the added millions recommended by Von Braun for Saturn will be made available, there is no doubt that NASA's budget for fiscal 1961 will be up sharply from the half-billion voted for the current year. A big boost became inevitable after the launching of Lunik II.

In the current fiscal year, the ABMA operation at Huntsville was funded at about $446 million, including $79 million for Saturn and other ARPA projects. NASA had about $20 million in work there, primarily for Redstone and Jupiter space boosters. Other projects funded this year at ABMA are $210 million in Army and $124 mil-

more on next page

lion in USAF (Jupiter) work. About $13.4 million is allocated for atomic defense support.

THE SATURN PROGRAM to date has included $36 million in fiscal '59 and $70 million in fiscal '60. The Defense Department will be seeking $140 million in fiscal '61, which will be transferred to NASA when it takes over the Saturn. As much as $250 million may be allocated for the project in '62.

Some current estimates are that the Saturn will end up costing a total of $800 million, or about $20 million per vehicle. The present schedule calls for the static firing of the first stage next spring and preflight test with dummy upper stages in mid-'61. The first actual space probe is to be launched between late '63 and '65.

Three possibilities for the Saturn's second stage

LEADING CANDIDATES for Saturn's second stage are an off-the-shelf Titan, a Centaur, and a projected four-engine vehicle. A winged vehicle is being considered for the top stage. It would weigh as much as 15 tons and would be lifted into a 300-mile orbit. But a winged top stage would be basically unstable, and the ABMA scientists working on a design with such a stage are having their troubles.

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ALTHOUGH THEY DON'T yet have a cabinet member to handle space and aeronautical sciences, the British have already gone far in that direction. The new Macmillan government has created the new Ministry of Aviation and put it under Duncan Sandys.

According to Sandys, his post is designed "to strengthen the structure of the British aircraft industry and to promote the expansion of the British air services. This will be much facilitated by the Prime Minister's decision to give a single minister responsibility for both aircraft production and civil aviation."

Jobs of two ministries are combined under Sandys

SANDYS HAS TAKEN OVER the civil aviation responsibilities formerly entrusted to the Ministry of Transport and Civil Aviation. He has also assumed the functions of the abandoned Ministry of Supply relating to civil and military planes, guided missiles, atomic weapons, radar, and electronics.

Although space activities are not part of his domain, Sandys' new post marks the first step by a Western powers to put aviation activities on the cabinet level. The U. S., which has much more extensive aircraft, missile, electronic and space activities than Great Britain, will be watching Sandys carefully to determine whether the British precedent is worth following.

Powerplants do well successful flight of Nike-Zeus test vehicle

PENTAGON OFFICIALS are pleased with the successful firing of a Nike-Zeus research vehicle at White Sands, N. M., even though the flight ended prematurely after it had reached the coasting phase. They believe they gained important information on the flight and propulsion characteristics of the anti-ICBM missile. Both the Thiokol 400,000-lb thrust solid rocket in the booster and the Grand Central Rocket second-stage sustainer performed successfully.

HOWEVER, we are still far from the development of successful defenses against ballistic missiles. George P. Sutton, ARPA's chief scientist, recently pointed out that failure to obtain a "satisfactory and relatively interference-free environment may seriously compromise the effectiveness of our defense system."

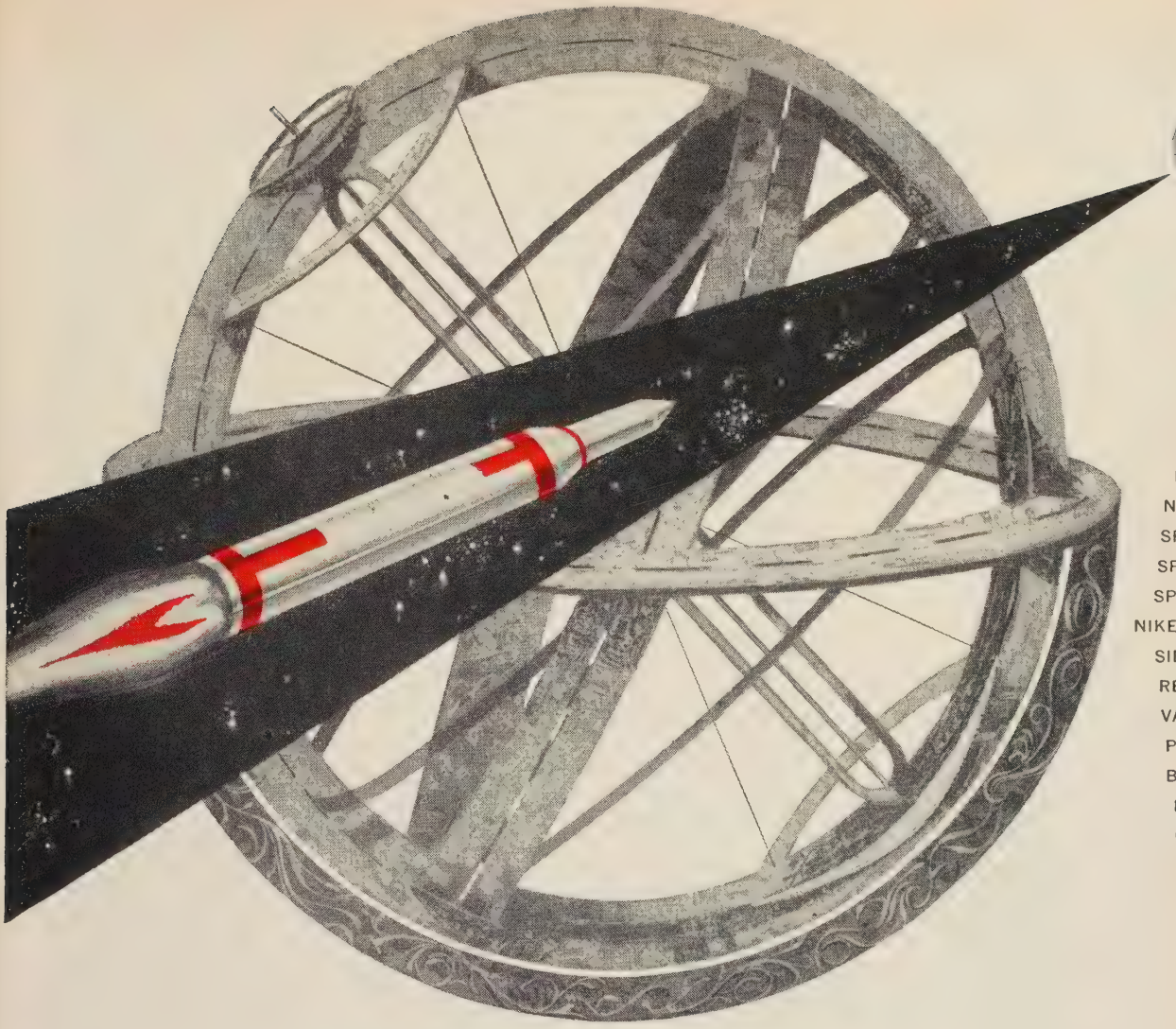
Typical requirements for an adequate defense system against ballistic missiles were listed by Sutton:

- wide-coverage radars for acquisition of enemy missiles,
- special tracking radars for following the courses of the missiles, predicting their impact points, and discriminating between warheads and decoys,
- transmitting equipment to carry the tracking data to a computing center,
- suitable interceptor missiles,
- automatic control of the intercepter missiles,
- transmission equipment to command the safety, warhead detonation, and destruct mechanism of the interceptor missiles.

•

PENTAGON'S REVISION of Section XV (on contract cost principles) of the Armed Services Procurement Regulation includes a significant allowance for general and applied research. Officials of the Aerospace Industries Association have adopted a "wait-and-see" attitude before reaching

more on page 26



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At speeds up to 24,000 RPM precision rotor bearings in inertial guidance and navigational systems are highly critical components. Early research and development in design and manufacturing at New Departure is solving the problem and thus winning vital roles for N.D. integral rotor bearings in missile projects. For example, "B" Series bearings with separable inner ring developed by N.D. are helping set performance records in such inertial guidance systems as the AChiever.

New Departure is also supplying high-precision rotor bearings for the inertial guidance system in Polaris.

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any conclusions about the possible benefits of this change.

Section XV now provides that a contractor's independent R&D costs are allowable as indirect costs if they are reasonable and the development is related to Government contracts. Included as allowable are some indirect and administrative costs. Contractors' expenditures are supposed to follow "a broad, planned program which is reasonable in scope and well managed.

Plans for independent R&D to be included in contract

AIA OFFICIALS point out there may not be much gain, because some past contracts have included provisions for general research and others have not. In other words, some firms may get less in the future as allowable research, others more.

DOD is proposing that U.S.-contractor agreements in this area cover a review of the contractor's proposed R&D program and an agreement on the maximum amount to be spent on the project. The government would then allow a specific part of this amount as a legitimate indirect cost.

The ASPR revision also covers such diverse items as advertising costs, executive profit-sharing plans, contingency costs, depreciation allowances, excess facility costs, interest, material cost allowances, plant reconversion costs, state and local taxes, severance pay, termination costs, and training and educational costs.

•

WITH ROCKETDYNE already at work on two 1,500,000-lb thrust rockets, the Air Force and other interested agencies are getting ready to let contracts for much larger boosters. Both liquid and solid propellant engines are being considered:

- Thiokol believes a 10,000,000-lb thrust solid booster can be built with available techniques. The booster would operate for about one minute —long enough to kick a huge payload out of the earth's gravitational field.
- Maj. Gen. Victor R. Haugen, USAF's director of development planning, indicates USAF will soon let a contract to study the feasibility of a solid engine twice as large as any now under development.
- Aerojet-General's proposed Project Cosmos would use a liquid booster delivering 6,000,000 - 14,000,000 lb thrust. If work on it were started at once, this vehicle would get man to the moon in four years, Aerojet-General claims.

CONVINCED that there is too much production capacity for a shrinking aircraft and expanding missile program, the Air Force is planning to sell off about 50 government-owned plants to the companies occupying them. It hopes the companies that buy the relatively new facilities will retire the older, less efficient plants they now occupy. Under the plan, plants considered "excess to ownership" will be cleared through AMC, USAF Headquarters, DOD, and Congress' Armed Services Committees once a "reasonable" offer is received. Once all parties agree, the actual sale will be negotiated by the General Services Administration.

To date proposals have been received from Douglas for Santa Monica, from Northrop for Hawthorne, from GE for Johnson City, N.Y., and from Thompson Ramo Wooldridge for the tool plant at St. Catherines, Canada. Other facilities offered for sale to any interested party (not necessarily the occupying contractor) include the GM plant at Tonawanda, N.Y., the Ford J57 plant in Chicago, and one of the Curtiss-Wright installations at Wood-Ridge, N.J.

All plants are to be sold at "fair market value" with the stipulation that they could be used for defense output if an emergency arose.

USAF as its own prime contractor foreseen on space programs

A WARNING THAT USAF may have to become its own prime contractor as it assumes additional space responsibilities has come from Dr. Joseph V. Charyk, assistant secretary for R&D. He says there will be too many complications in combining booster, guidance and control systems, and payload package into a single vehicle. Therefore the management part of the program may have to remain USAF's responsibility.

•

STUDIES by the Pentagon's research director, Dr. Herbert F. York, have led to the decision not to change the arrangement under which the Air Force and the Atomic Energy Commission share in the development of the nuclear-powered aircraft. Brig. Gen. Irving L. Branch, who replaced the retired Maj. Gen. Donald Keirn, will head the ANP operation for both his service and the AEC.

But at least one change, which should produce a more advanced engine with higher performance, is in the works: AEC is putting added emphasis on the development of advanced fuel elements for the program's direct-cycle GE X-211 engine.

FROM LAGRANGIAN TO LIFT-OFF

Sometimes forgotten during the thundering ascent of a space probe rocket are months of meticulous analysis, engineering and planning. The staff of Space Technology Laboratories is now engaged in a broad program of space research for the Air Force, the National Aeronautics and Space Administration and the Advanced Research Projects Agency under the direction of the Air Force Ballistic Missile Division. For space probe projects STL provides the total concept approach, including preliminary analysis, sub-system development, design, fabrication, testing, launch operations and data evaluation. The total task requires subtle original analysis in many fields as well as sound technical management.

The STL technical staff brings to this space research the talents which have provided system engineering and technical direction since 1954 to the Air Force Ballistic Missile Program. Major missile systems currently in this program are Atlas, Titan, Thor and Minuteman.

The scope of STL's responsibilities offers creative engineers, physicists and mathematicians unusual opportunities to see their ideas tested in working hardware. Inquiries are invited regarding staff openings in the areas of Advanced Systems Analysis, Rocket Propulsion, Space Flight Mechanics, Dynamics, Structural Analysis, and Aerodynamics.

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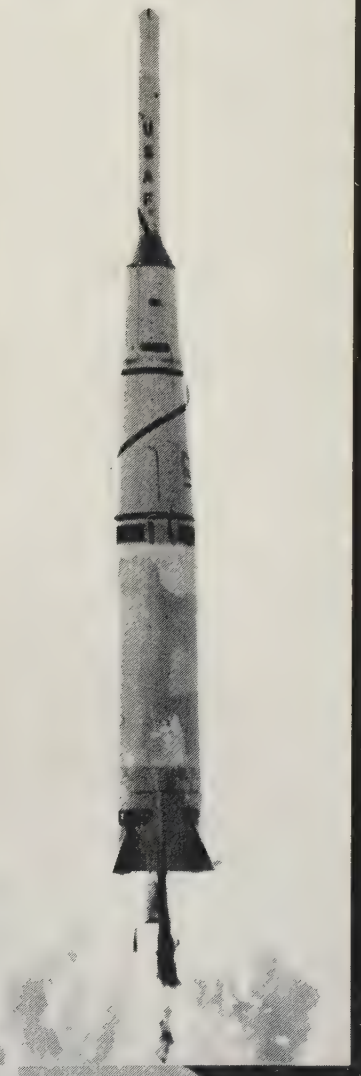

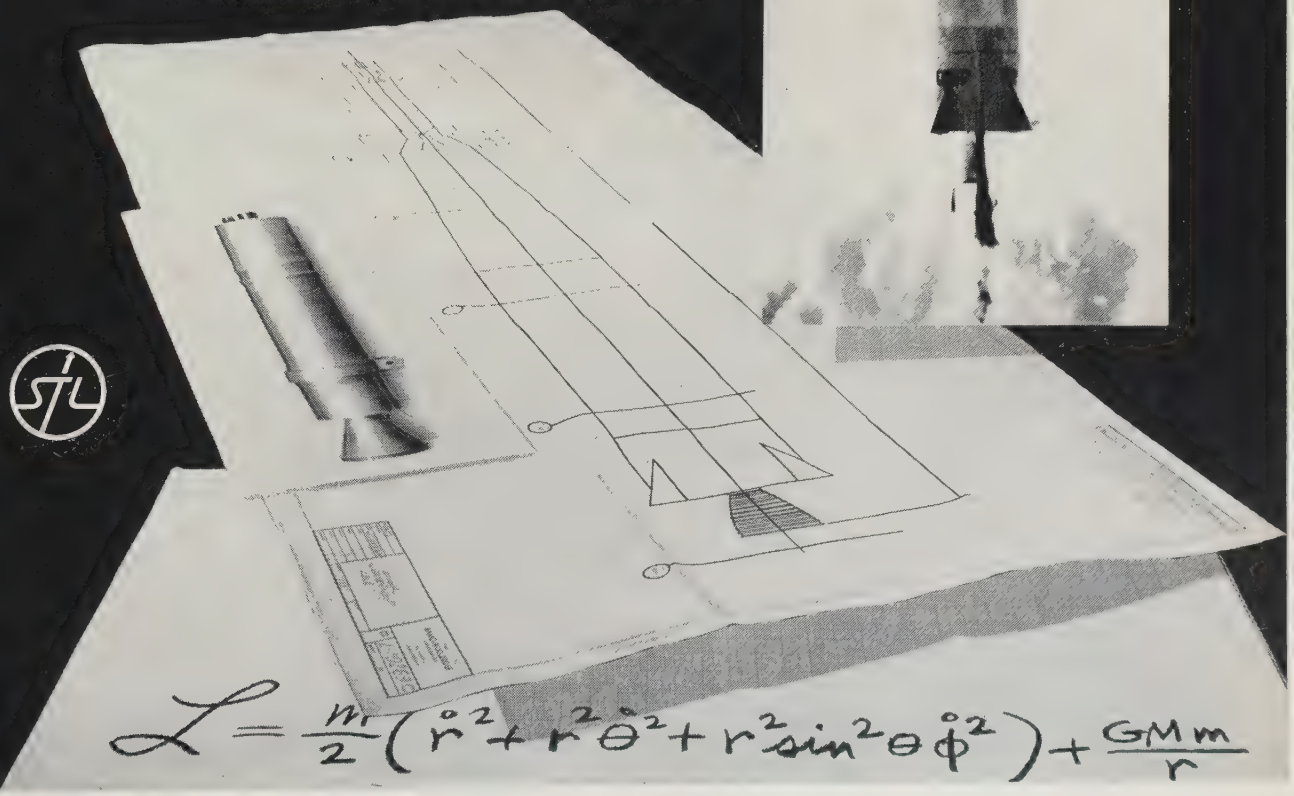

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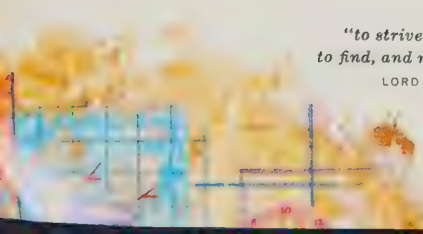

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Electric motors for operation in 600° F at 80,000 ft

HIGH TEMPERATURE electric motors that can operate continuously or intermittently in 600 deg F ambient at 80,000 ft were developed by AiResearch for North American. Built for Mach 3 aircraft—presumably of the B-70 type—they can operate on single- or three-phase or in a servo control system.

AiResearch is producing different motors to provide 0.05 hp intermittently, 0.5 hp continuously, and 15 hp continuously. It is also working on units for the 700-800-deg F range.

■

NEW "B" VERSION of C-133 has special clamshell doors that open in four directions so ICBMs can be loaded. Recently it flew a fully assembled Atlas from San Diego, Calif., to Cheyenne, Wyo. A track system is installed inside the plane for use in loading missiles.

The C-133B, Douglas states, will carry over 26 tons payload 4000 miles at an average speed of 323 mph. The four engines are T34-9W turboprops.

Aluminum rivets may lick corrosion problems of metal contact

HIGH PURITY aluminum rivets for magnesium structures may solve the problem of high temperature corrosion due to the contact of dissimilar metals, J. L. Nichols, of Dow Metal Products, reports. The most compatible material has been known to be 5056 aluminum, but the ordinary commercial version of this alloy has shown poor high temperature properties. Now new tests of 99.99 per cent pure 5056-H32 rivets at Dow Metal Products' metallurgical lab have indicated adequate shear strength and compatibility for this alloy over most of the temperature range up to 800 deg F. The test involved 100 hours' exposure to 20 per cent salt spray and panels made from AZ31B, HK31A-H24, and HM21A-T8 magnesium and sealed with vinyl coating.

Aging of the aluminum material—for ¾, 10, and 100 hours at 800, 700, 600, 500, 400, 300 and 200 deg F—did not impair the galvanic compatibility states Nichols. Double shear pin tests of 5056-H32 rivets at all three aging conditions showed shear strengths of about 7000 psi at 700 deg F and of 10,800-11,800 psi at 600 deg F.

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FIRST SETBACK IN X-15 PROGRAM occurred on Nov. 5 with the failure of a powered flight. In this third powered flight of the plane, speeds of Mach 2 and an altitude of 80,000 ft were to have been reached.

North American officials told SPACE/AERONAUTICS that pilot Scott Crossfield reported that the launch from a B-52 at 45,000 ft went off normally. Crossfield ignited all four chambers of the top engine without trouble. When he ignited the first (top) chamber of the lower engine, an explosion occurred that he could feel. The F-104 chase plane immediately radioed that it had spotted a fire.

Crossfield jettisoned his fuel, then saw the fire warning light on his instrument panel was out and decided to land.

Bottom of fuselage cracked open in accident during powered flight of X-15

THE X-15 LANDING, which took place five minutes after launch, seemed perfectly normal, the chase plane and ground observer reported. The skids and the nose wheel apparently touched down in the proper position. A few instants after the nose wheel had touched down, however, the bottom of the fuselage just aft of the cockpit literally broke open (roughly where the cockpit, or first, fuselage section and the second fuselage section are welded together). The crack extended all the way across the bottom of the fuselage.

NAA THINKS the explosion occurred in the forward end of the lower bay and might have been due to fuel leakage. It doesn't know whether the fuselage cracked because the landing was unusually hard or because the explosion had weakened the structure.

The damaged plane, the second of the three X-15s that have been built, can be repaired in a few weeks, NAA believes. However, if the damage is more extensive than expected, the plane might be virtually scrapped in a detailed investigation. Plane No. 1 has not been used yet—it's slated to be ready for use in the near future.

■

"SPACE FERRY" was proposed jointly by Hughes Aircraft and Lockheed. It would carry a pilot, three passengers, and materials to an orbital station for assembly or supply work.

more on next page

At launch, the folding-arrow-wing vehicle would be mounted on top of a three stage-rocket of 1,000,000 lb gross weight. The wing would enclose a cylindrical container holding a 14,000 lb payload, including the crew. The rocket would be programed for automatic guidance through three basic propulsion stages.

Near its target station, the vehicle would change from the symmetrical arrowhead configuration by unfolding its 1000-sq ft flying wing and exposing the payload cylinder. During re-entry, a Hughes system would control extreme temperatures and smooth out the flight path to give a gentle glide approach.

Capsule of space ferry could be mounted on different carrier vehicles

ORBITAL INJECTION WEIGHT would vary from 20,000-32,000 lb, depending on orbital altitude. Atmospheric control would be accomplished by elevons and drag rudders, control in space by 12 reaction jets. The ferry also would have a throttleable 7500-lb thrust engine for maneuvering in space, retro-firing, and landing assistance.

The payload capsules would be used with several carrier designs. The ferry would use corrugation-stiffened thin sheet for its aerodynamic surfaces and open truss for the basic support structure. Its empty weight would be 11,000 lb.

Hughes and Lockheed officials said their companies' studies showed the ferry system would be feasible by '65 or '66.

■

PURE RARE-EARTH metals may become available in abundant quantities at reasonable cost if promising new methods of separation prove out, WADC sponsored study reports. Good progress has been made in the reduction of separated compounds of metals like yttrium, scandium, cerium, lutetium, rhodium, ruthenium, hafnium, etc., to the metallic state in previously unobtainable purities.

Equipment costs lowered by new chem-milling process

HONEYCOMB CHEM-MILLING method was developed by Northrop's Norair Div. It consists of pressing a block of honeycomb core into a frangible, water-dispersible "negative" representing the reverse of the desired contour. The exposed honeycomb cells are then masked, the negative is dissolved, and the unmasked honeycomb is removed by chem-milling. The process is now being refined; it will be licensed by Turco Products' Chem-Mill Div.

Norair reports the new method cuts capital equipment costs for operations now performed by a crushing press or machine milling. In one case, the cost of a vertical-stabilizer leading edge was cut from $361 to $27 per unit. The first production facility for the new process is being installed at Norair to make parts for the T-38 and N-156F.

■

REFRACTORY METALS will come along rapidly and be used more and more widely as materials of construction for advanced aircraft and missile systems, R. I. Jaffee, of Battelle Memorial Institute, told the recent International Symposium on High Temperature Technology at Stanford Research Institute, Menlo Park, Calif. He predicted these major developments:

- discovery of added sources of tantalum and rhenium throughout the world;
- the development of electron-beam melting to make it as important for consolidating refractory metals; sintering and arc-melting;
- the discovery of alternatives for rhenium for improving the breakdown fabrication of case molybdenum and tungsten;
- the development of chromium sheet products with reasonable (though not good) low temperature ductility;
- the development of oxidation protection systems for refractory metals, so that the range of application will no longer be limited by oxidation failure.

Use of graphite cloth foreseen in high temperature reinforcement design

GRAPHITE CLOTH appears to have major potential as a reinforcing material for high temperature plastics, ceramics, and refractories for rocket nozzles, nose cones, etc., L. M. Litz, of National Carbon's Cleveland Research Labs, told the SRI conference. Individual graphite yarns have shown tensile strengths as high as 15,000 psi, he stated. The material has been processed to temperatures of about 5400 deg F and still remained flexible, said Litz.

LITZ ALSO DISCUSSED carbides, nitrides, and sulfides. Boron nitride, he notes, has been studied

more on page 32

59-4

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as a possible high temperature capacitor material. It has also been used as a thermal insulator at about 2000 deg C in a vacuum and up to 3000 deg C in nitrogen and ammonia atmospheres. Other nitrides are also being studied for high temperature uses, including those of aluminum, silicon, and titanium.

Sulfides, Litz told the conference, in many cases have higher melting points than the refractory oxides. Cerium monosulfide, for instance, can be heated in a high vacuum to 1900-2000 deg C without excessive decomposition or evaporation; thorium monosulfide can go even higher. However, these sulfides are very susceptible to chemical attack—they are soluble in dilute acids and oxidize when exposed to air at temperatures of about 200 deg C. Some sulfides have been studied in the search for crucibles in which to melt the more active metals without contamination from oxygen, Litz reported.

Low density, high melting points, chemical stability and high hardness

SILICIDES AND BORIDES have many attractive properties in common, J. H. Westbrook told the symposium: low density, high melting point, chemical stability, high hardness. The borides have poor oxidation resistance above 1300 deg C, but the silicides, which quickly form stable protective coatings of silica, have excellent oxidation resistance in air even at temperatures approaching their melting points, Westbrook stated. The main problem before any of these compounds can find use as a bulk material is to develop suitable bonding materials.

As coatings for graphite and refractory metals, said Westbrook, the silicides or silicides based compositions need little further improvement.

•

GAS BEARING symposium sponsored by Office of Naval Research in October was attended by engineers from all over the world. It was reported that applications for gas bearings are now being considered that call for temperatures ranging from about —450 deg F to almost +3000 deg F.

HIGH TEMPERATURE, high pressure pump developed by Rocketdyne was licensed for sale by Fairchild Engine & Airplane. Credit for the development is given to Knut Henrichsen of Rocketdyne's special turbopump design section.

Chief design features are the application of hydrostatic and hydrodynamic bearing principles on all major sliding surfaces and use of all-steel construction. According to Rocketdyne, the pump can operate at very low fluid viscosities.

RUSSIAN MOON PHOTOS reportedly were taken by "normal" camera aboard the satellite, developed automatically in flight, and then transmitted to earth by a combination of TV and a "special radio system." Russians claim results are superior to electronic TV scanner photo transmission.

Three tons of propellant per second to be pumped into giant rocket booster

SINGLE-CHAMBER 1,500,000 lb thrust F-1 engine under development at Rocketdyne will pump RP-1 fuel and liquid oxygen into the combustion chamber at a rate of almost three tons/-sec. The injector for the F-1 has already been tested at over 1,000,000 lb thrust. Reports are the complete development will take 4-5 years.

•

EXPLODING BRIDGE WIRE (EBW) technique developed by Librascope-Sunnyvale should find extensive use in warheads, rocket initiators, stage separation systems, and thrust termination designs. A high energy pulse fed to a wire filament causes the wire to explode with tremendous force. High temperature and the pressure shock wave set off secondary explosive material. Beauty of the exploding bridge wire is that neither stray low voltage potentials nor high energy RF fields can trigger a premature explosion.

EBW SYSTEM is also a big weight saver, says Librascope. In a typical IRBM application, it claims, the exploding wire system weighs much less than a conventional squib detonating system —nine pounds as against 26 lb.

Solid propellant turbostarter for B-70 works in less than half a minute

B-70 ENGINE will be started in less than 30 seconds, according to General Electric. Self-contained turbostarter that will use a solid propellant energy source was developed at GE's Aircraft Accessory Turbine Dept., Lynn, Mass.

more on page 34

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UNDERWATER TV VEHICLE has been developed to study the ocean bottom. It is equipped with closed-circuit television, underwater lighting, and a movable camera housing that can be trained 70 deg in any direction.

The system is remotely controlled by a surface vessel through a multi-conductor cable. Its electric propulsion system enables the vehicle to descend and hover at great depths in currents and tides of several knots. Navy reports successful bottom survey operations at depths of more than 600 ft.

JET-POWERED BELL X-14 VTOL was delivered to NASA for advanced flight testing. It takes off and lands in a normal horizontal position. Vanes deflect thrust downward for takeoff and rearward for forward flight.

Ten million pounds thrust for one minute from solid rocket predicted

SOLID BOOSTER MOTOR with 10,000,000 lb thrust and 60 seconds duration was proposed by Dr. H. W. Ritchey, of Thiokol. According to Ritchey, it would take only three years to develop such a motor.

The proposed motor is about 20 ft in diameter, 107 ft long, and weighs somewhat less than 3,000,000 lb. Excluding the initial development program, Ritchey estimates the unit cost would be about $3,800,000—about one-third of what it would cost to get a comparable thrust with any other known methods of propulsion.

•

CONWAY BYPASS engines to be fitted to the Boeing 707-420 and Douglas DC-8 jets will have a 17,500 lb guaranteed minimum takeoff thrust instead of specified 16,500 lb rating. Increase in thrust has come some 12-18 months earlier than promised.

De Havilland Gyron Junior to power Bristol T-118

BRITAIN'S STAINLESS STEEL Bristol T-118 research plane will be powered by de Havilland's DGJ-10 Gyron Jr. turbojet engine. The DGJ-10 has a sea level static thrust of 10,000 lb. Total frontal area is less than six square feet.

•

NUCLEAR ENGINEERS at GE's Aircraft Nuclear Propulsion Dept. are backing the direct-cycle engine for nuclear-powered aircraft. Dr. M. C. Leverett and W. F. Savage of GE reported before an ARDC area meeting that it seems likely the direct-cycle type can be developed into a subsonic powerplant of good performance. They also said that supersonic direct-cycle engines appear feasible.

Their predictions are based on the fact that relatively many materials appear to be able to take very high turbine temperatures. High thrust levels therefore can be achieved. The GE engineers pointed out, however, that turbine operating limits may well keep us from making use of the full capabilities of an airborne reactor.

AF OFFICIALS can't get together over the most suitable powerplant for the projected military cargo plane. Some believe no present turbofan is suitable and want a turboprop like the Allison T61 procured as an interim engine.

AF WILL GO AHEAD with the GAR-9 Super Falcon and its ASG-18 fire-control system even though the F-108 interceptor has been canceled. Although there are no firm decisions as to how the Super Falcon will now be used, Hughes is getting additional development contracts. A modified Convair B-58 is on bailment to Hughes for GAR-8 and ASG-18 testing.

JetStar wins out over McDonnell 119 for AF training

AF PICKED the Lockheed 329 JetStar over the McDonnell 119A as its utility plane to train bombardier-navigators. But the AF does not know whether it will be able to find enough money to fund the JetStar in fiscal '60.

•

NAVY IS INSTALLING the latest anti-sub detection equipment in 85 P5M-2 Marlins. Following up a $15.4 million contract to modernize 28 Marlins, the Navy gave Martin a $30.6 million award to update 57 more patrol seaplanes.

MINUTEMAN has been fired successfully in model form from underground silos.

BOEING offered to start production of the Model 735 jet freighter for military or civil buyers. A swing-tail version of the 707, it will be powered by a P&WA turbofan and capable of hauling 100,000 lb across the U. S. in five hours. Operating costs, Boeing claims, will be as low as three cents per ton-mile.

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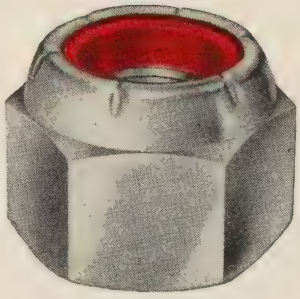

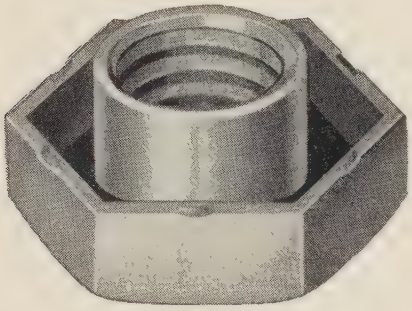

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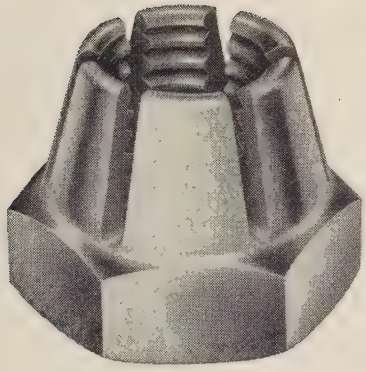

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CAPACITOR

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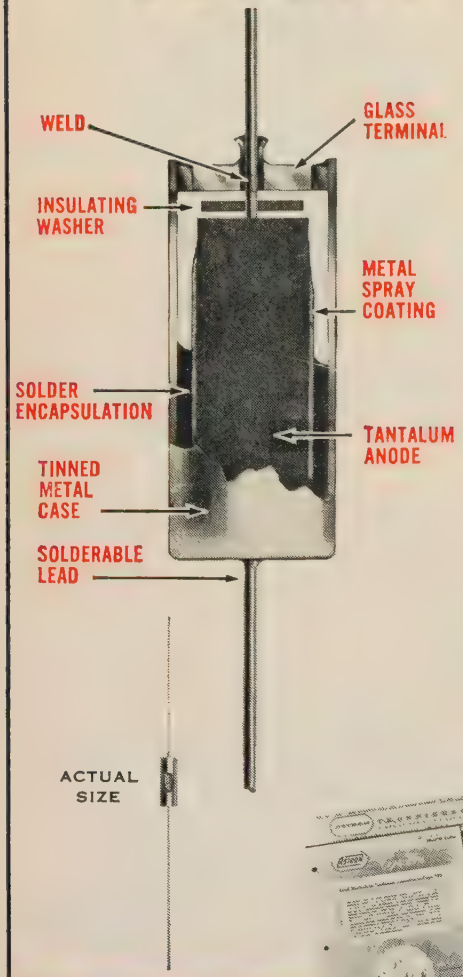

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Wet Tantalum Slug**	.8
Etched Tantalum Foil**	4.5
Aluminum Electrolytic**	12
Metallized Mylar†	64
Metallized Paper	68
Paper*	130
Foil Mylar†	210

*INSERTED TAB
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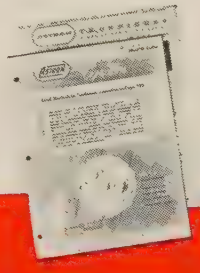

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SPECIALISTS IN CAPACITOR MINIATURIZATION

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calendar

December 6-9—52nd Annual Meeting, American Institute of Chemical Engineers, Sheraton-Palace, San Francisco, Calif.

December 7-8 — Classified Symposium on "The Plasma Sheath, Its Effect on Communication and Detection", Electronics Research Directorate, Air Force Cambridge Research Center, Boston, Mass.

December 7-11—National Conference on the Application of Electrical Insulation, American Institute of Electrical Engineers, National Electrical Manufacturers Assn., Sheraton Park Hotel, Washington, D. C.

December 8-9—First Aerospace Finishing Symposium, Society of Aircraft Materials and Process Engineers, Dallas-Fort Worth Branch of the American Electroplaters Society, Hotel Texas, Fort Worth, Texas.

December 17—23rd Wright Brothers Lecture, Natural History Bldg. Dr. Alexander H. Flax, Chief Air Force Scientist, will speak on "High Temperatures in Hypersonic Flow—Physical Principals and Experimental Techniques", Smithsonian Institution, Washington, D. C.

January 11-13—Sixth National Symposium on Reliability and Quality Control in Electronics, Statler-Hilton Hotel, Washington, D. C.

January 12-16—16th Annual Technical Conference, Society of Plastics Engineers, Conrad Hilton Hotel, Chicago, Ill.

January 14-20—Sixth Annual Meeting, American Astronautical Society, Statler-Hilton Hotel, New York, N. Y.

January 25-28—28th Annual Meeting, Institute of the Aeronautical Sciences, Hotel Astor, New York, N. Y. Honors Night Dinner, Jan. 26.

January 28-29—Solid Propellants Conference, American Rocket Society, Princeton University, Princeton, N. J.

February 2-4—Fifteenth Conference of the Society of the Plastics Industry, Reinforced Plastics Division, Edgewater Beach Hotel, Chicago, Ill.

February 3-4—Sixth Annual Midwest Welding Conference, Armour Research Foundation of Illinois Institute of Technology; Chicago Section, American Welding Society; Illinois Tech Chemistry Bldg., Chicago, Ill.

February 3-5—1960 Winter Convention on Military Electronics, Institute of Radio Engineers, Ambassador Hotel, Los Angeles, Calif.

March 10-11—National Flight Propulsion Meeting (Classified), Cleveland, Ohio.

April 6-8—Structural Design of Space Vehicles Conference, American Rocket Society, Biltmore Hotel, Santa Barbara, Calif.

April 8-9—Seventeenth Western Section Conference, The Society of the Plastics Industry, New Riviera Hotel, Palm Springs, Calif.

April 19-21—"Symposium on Active Networks and Feedback Systems", Auditorium of the Engineering Societies Building, 33 West 39 St., New York, N. Y.

April 20-22—National Symposium on Manned Space Stations, Ambassador Hotel, Los Angeles, Calif.

April 21-22—Southwest Metals and Minerals Conference, Ambassador Hotel, Los Angeles, Calif.

April 21-28—Annual Meeting of American Society of Tool Engineers, Aeronautical Systems Center's Manufacturing Methods Division of Air Material Command, Detroit, Mich.

April 25-26—Eighteenth Annual Conference, The Society of the Plastics Industry, Canadian Section, London Hotel, London, Ont., Canada.

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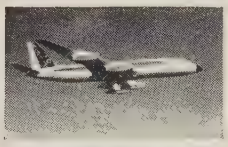

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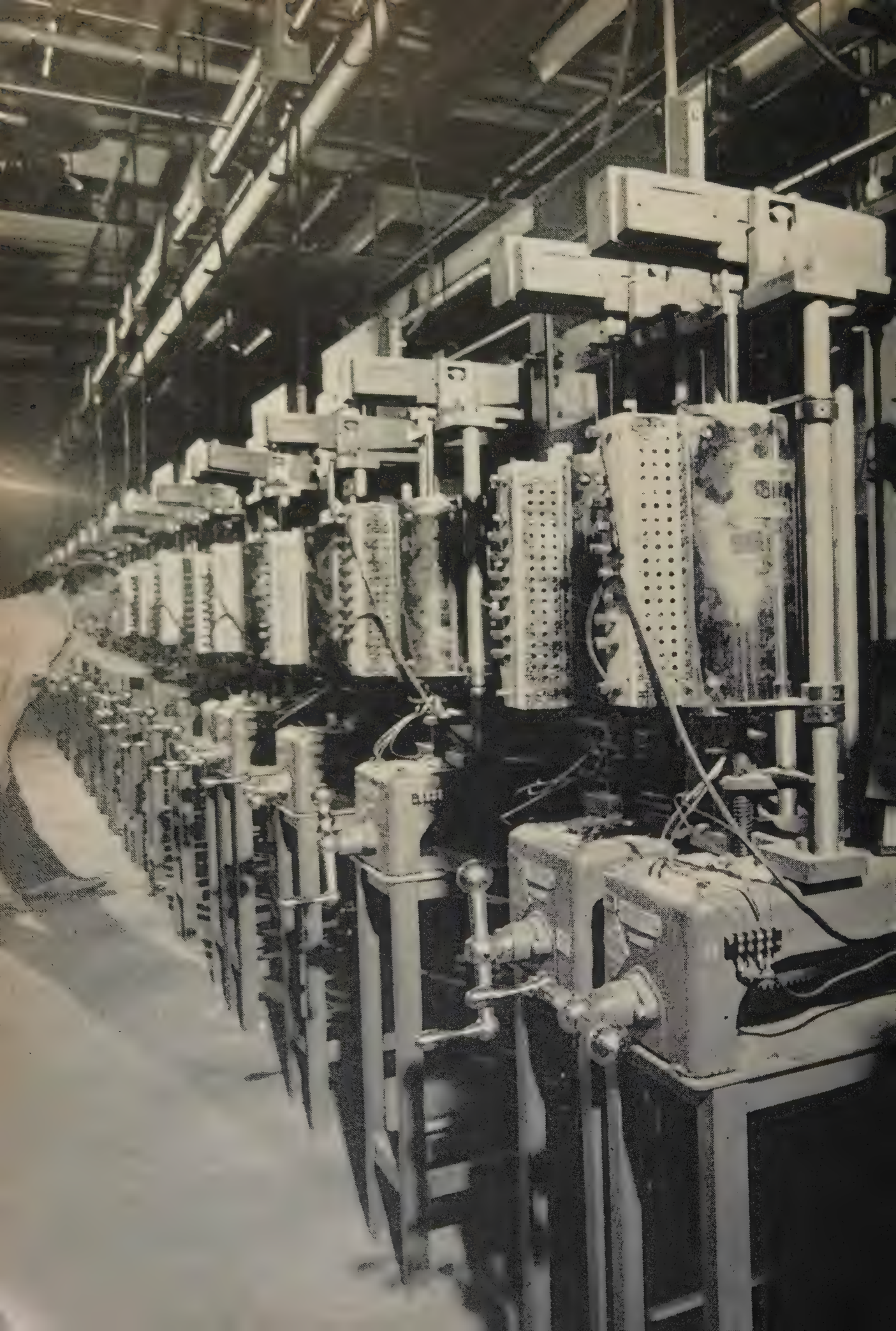

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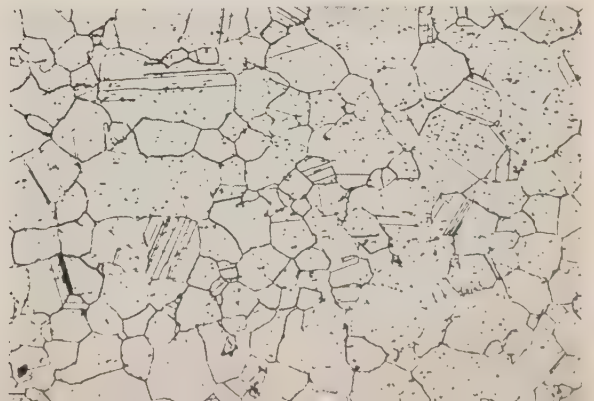
Over 100 stress testing machines (left) test high temperature properties of every alloy heat at Metals Division. Uniform grain structure and evenly distributed carbides contribute to remarkable stress-rupture life.



Why we lag in missile and space programs

Since the Russians hit the moon a few months back, even our government leaders have admitted that our missile and space programs lag behind the Reds'. Can we overcome this lag? Yes—if there's a radical change in our approach to the problem.

by Randolph Hawthorne, Editor

WHY DOES THE U. S. lag in space flight and missile programs? How is it that a people noted for its genius for organization, for its daring in tackling the unknown and the impossible and putting them on a sound production basis, can show so little backbone in matters that affect vitally its future as a nation?

The reason is lack of vision at the top. The results of this lack are torpid leadership and indecision, coupled with an uninformed public deliberately kept uninformed.

The Dyna-Soar program is a prime example of a decade of indecision and wasted effort by the U.S. Air Force and Defense Department. "Study" contract after "study" contract has been let, and thousands of man-hours have been frittered away. Yet the thesis of an "antipodal", or semi-orbital, bomber was first developed by Sänger in Germany in 1943!

The Dyna-Soar concept could be the quickest answer to the problems of manned orbital flight. At the same time it could prove the "ultimate" bomber. But procrastination and limp push for dollars by the upper Air Force echelon, afraid to risk their careers to fight for their convictions against political considerations, have almost killed this project.

Billions of dollars have been spent without much good result. Why? Because in two Administrations the President and top officials refused to see what was shoved under their noses for years. When events caught up with them, we were forced into "crash" programs to catch up with the Soviets. We are still trying to catch up—at enormous cost to the taxpayer. Mistakes, bound to happen in a "crash" program, would not have happened in a systematic development program.

All of this has been pointed out by the technical trade press, by industry leaders, and by military leaders over the years. There simply isn't a shred of an excuse that can be offered by either the Truman or the Eisenhower Administrations for our present dangerous lag in missiles and spacecraft.

Neither can they plead that there was no public support for spending the sums needed for the right programs. Their own bureaucracies have seen to it, and still see to it, that the public isn't properly informed of the danger we face, and of what is needed to meet it. Nor has either President seen fit during his term to warn the public clearly and firmly of the danger which has loomed larger every year since 1946. What little space program we now have was forced upon President Eisenhower by a public stirred by the first sputniks.

Neither can they say that we cannot afford the necessary programs because of high costs. The billions of dollars now wasted in the "crash" programs forced by Soviet progress would have been saved by a systematic, planned development. Billions more dollars are wasted on agricultural and other welfare programs that are secondary to our survival as a nation. Leadership by the President against such spending would reduce it to controllable levels, as was shown by President Eisenhower's effective intervention in the recent drive for labor legislation.

What are the objectives?

What are the U.S. space objectives? A review of our national space program makes clear that the country does not yet have a singleness of purpose and determination to treat space as a new dimension, worthy of great national effort. The National Aeronautics & Space Administration (NASA) is trying to do a heroic job. But $500 million simply isn't enough for a cold war race in which space prestige is as important as military strength.

The scattering of agencies all over the country, with many government and industrial laboratories all competing, is expensive. It is expensive not only in facilities but also in the diversion and scattering of manpower and the lack of communication between all these organizations.

Very often almost identical proposals are made to the Pentagon (sometimes to the same office, sometimes to separate, "competing" offices), without the proposal makers' being aware beforehand of this duplication.

The Saturn booster—America's only big booster for the near future—was almost scuttled by the Air Force, which wanted to "soup up" the present ICBMs at a colossal cost in dollars and time.

One of the great tragedies of this country is the hat-in-hand attitude that industry must take to get contracts. Thousands of proposals on space activities were presented between 1946 and 1958. Some of these proposals were brilliant and daring. They would have given the U.S. a great space capability.

As far back as 1948, at least two major aircraft companies submitted proposals on "minimum" satellite vehicles that would have given the U.S. a 30-lb satellite by 1953! Cynicism, bickering, and doubt—coupled with lack of imagination and money—killed these and other proposals.

Research has been badly managed

The reason why vast sums have been spent without good result is that this money went for poorly related and inapplicable research projects. Even when applicable, the results of such projects are rarely available to the engineer and designer. Hundreds of research contracts often have supported moss-grown university labs that are badly managed and administered. Vast sums also have been spent in industry and government labs on "rocket research", most of which went down the drain, using up good scientists' time and facilities.

Here are only a few of the efforts that have been supported to no good effect (but to the tune of millions of dollars in several cases):

• *Microwave and radar absorption in rocket and jet exhaust flames*—At least a dozen "study" and experimental contracts have been let by the Air Force and the Navy to universities (Michigan, for one), large rocket companies, and government labs. Yet today, 12 years after the first research began and several hundred reports later, most engineers working on missiles have little idea about telemetry attenuation by exhaust flames. The reports have not even been put together into a single volume.

• *Throttling rocket engines*—Aerojet-General, Bell Aircraft, Curtiss-Wright, Reaction Motors, Rocketdyne, and the University of Michigan, have all studied and built throttling engines. Facilities have been put up, many reports have been written, and we have an interesting variety of throttling engine and injector designs. What we don't have is a good throttling engine. There is not even a standard approach in the U.S. industry to this problem. Each design group has its own ideas and isn't informed about the work done by others. At least $20 million are down the drain—and more dollars are coming.

• *Ignition for rockets and ramjets*—Ignition and re-ignition of the engines are crucial for rocket aircraft, high altitude supersonic vehicles generally, and for space vehicles requiring re-starts. The Discoverer vehicles, for instance, need re-ignition, and so will several other planned deep-space probes. Every university rocket lab in the country and every industry rocket facility (as well as several government research centers) has tried to develop spark, plug, and chemical igniters. Several gross of reports on mechanical, electric and chemical ignition schemes exist.

Bids for work that's already done

Yet several companies are now bidding for such research, proposing to do work that mostly has been done already—only the results are not available, since the reports are buried in government and industry libraries. There usually is neither enough money nor enough trained library personnel to catalog, edit, and publish the reports. The libraries at Wright Field, the Air Force Office of Scientific Research, and BuAer have hundreds of reports—guarded from study by serious researchers with outrageous jealousy and silly need-to-know rules.

• *High-energy propellants*—A conservative estimate of the cost of the work in this area is $250 million—spent since 1946 on studies, "research", and facilities. As an example, take the diborane and boro-hydride work done at the facility of a large company. A big pilot plant was set up, many reports were written, several men were killed, years of work were done, and for what? The sponsoring military agencies had changes of command, and therefore outlook, budgets were trimmed, no one was able to make a decision on the efficacy of the new fuels. In the end, the company threw in the sponge.

Aerojet-General, Allied Chemical, Armour Research, Bell Aircraft, Jet Propulsion Labs, NASA's Lewis Propulsion Lab, the University of Michigan, Monsanto Chemical, the Naval Aircraft Rocket Test Station, Ohio State, Pennsylvania Salt, Phillips Petroleum, Princeton, Purdue, Reaction Motors, Rocketdyne—all spent tens of millions of dollars on research on fluorine, fluorine compounds, hydrogen-oxygen, metallic-organic fuels, ozone, monopropellants (propyl-nitrate, nitro-methane, etc.), and thousands of other compounds. What do we have today? By far the commonest propellant combination is still LOX-JP, developed and first used around 1926 by Dr. Goddard! Again, poor direction and little coordination by the services.

No rocket launch base in the U.S. can handle fluorine —and the personnel are bitterly resisting the use of this oxidizer.

Failure on boron was predicted

And now the entire boron program has been cut back. The trouble is that it was 10 years ago that several combustion engineers first warned that boron fuels would add little to rocket efficiency, and would cause severe erosion, storage, and pumping problems in jets.

As long as poor, wilfully poor, vision exists, coupled with bad planning and weak policy, and we have no proper information exchange and no long range, systematic development programs, the U.S. will bump along on one "crash" program after another.

It will cost like blazes, and we shall come out second best.—End

Chemical propulsion:

state of the art

The basic reason why we are lagging in the missile and space race is that the Russian's high thrust powerplants are more powerful than ours. In no other technical field, therefore, are our attempts to get higher performance more critical than in propulsion.

by Kurt R. Stehling,
Contributing Technical Editor

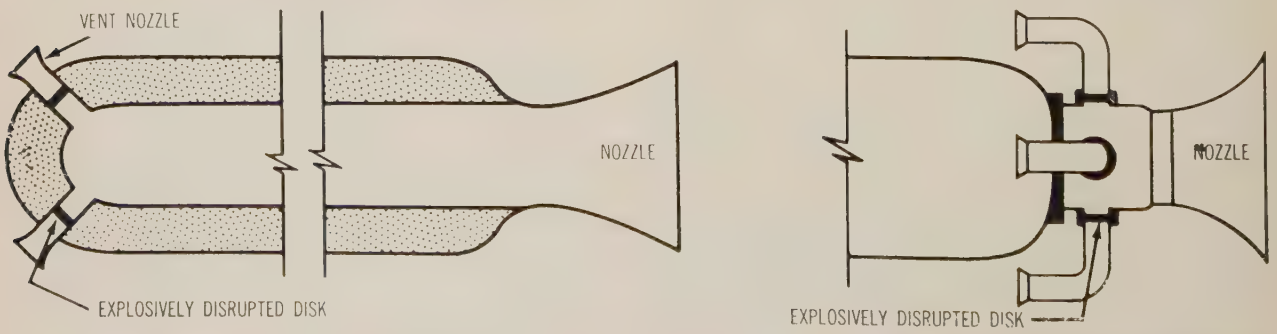
"EXOTIC," the dictionary says, means both "excitingly strange" and "extraneous". It is a good word, therefore, to be applied to the many advanced propulsion concepts put forward over the last few years.

From the nuclear rocket to the ion engine, from the plasma generator to the solar sail, these concepts are indeed exciting—we can tell that, once they have taken shape as operational hardware, they will undoubtedly advance propulsion as it has never been advanced before. But we can also tell that we will have to wait a long time before we have that hardware. And for that reason, the "exotic" propulsion concepts are in a sense extraneous today—they will not help us to advance our booster capabilities very much over the next decade, during wihch the race for supremacy in the missile and spacecraft fields may very well be decided.

Any advance in high thrust engines we will make during the sixties must come in chemical rocket propulsion. How far are we in this field now? How much farther can we go, and how much farther are we likely to go?

Because of all the publicity about "exotic" propulsion and its fantastic possibilities, the impression has been created that we will very soon reach the limits of chemical propulsion and that many of the space missions we would like to bring off over the next 20 years, say, exceed these limits. This impression is quite wrong. The potential of chemical rocket pro-

FIGURE 1: Thrust can be cut off in a few milliseconds by either of these vent arrangements. With the vent at the front of the chamber, the forward thrust component is stopped as well as the thrust-producing combustion.



pulsion definitely meets the requirements of space flight as it is likely to develop in the near future, and we are still very far from the full realization of this potential.

Just look back for a moment at the V-2 developed by the Germans toward the end of World War II. Burning alcohol and liquid oxygen (LOX), this missile had a thrust of 56,000 lb. Now compare it with an IRBM of 1958 vintage, which still burns LOX, though together with a better fuel, and has a thrust of 156,000 lb. The improvement in thrust-weight ratio has been 245 per cent; that in specific impulse, 50 per cent. As a result, either range is up by 125 per cent or payload by 285 per cent.

Old designs still used in rockets

In the mid-forties, the Germans had already developed rockets burning hydrocarbon fuels and nitric-acid oxidizers and others burning ammonia-like fuels (e.g., hydrazine) and hydrogen peroxide at more than 80 per cent concentration. They had regenerative cooling systems, propellant turbopumps driven by H_2O_2 decomposition gas, and jet vanes for vehicle control. In this country, several important liquid propellant combinations (including such hypergolic ones as aniline and nitric acid), the forerunners of today's solid propellants, and the regeneratively cooled thrust chamber were developed around the same time.

Most of these developments are still basic to rocket design today. Especially in propellants, where the greatest advances could have been scored, little progress was really made—for our large rockets, the hydrocarbons and LOX are still the favored propellants. Most of the improvements since 1945 have been in structural and component design and combustion efficiency:

- Higher chamber pressures have raised the thrust per pound of burned propellant. Especially above 500 psi, these pressures have involved us in problems of plumbing, valving, and nozzle liners, all of which must be more durable. Thanks to the use of high strength stainless steels and, in the case of solids, of plastic fiberglass or metallic chambers, it has often been possible to increase the chamber pressure without increasing the engine weight.

Simpler, more positive control

- By using gimbaled thrust chambers, designers have achieved simpler and more positive and economical control than they could get with exhaust jet vanes. These devices are complex, always erode in the end, no matter what they are made of, and interfere sufficiently with the exhaust to cut the specific impulse by 2-3 per cent. Gimbaled chambers do pose some problems—a powerful gimbal joint is needed, and so are hydraulic or pneumatic actuators and relatively complicated truss arrangements and thrust structures—but these are well in hand.
- On missiles up to the size of the Atlas, say, the propellant tank system has been pressurized and made an integral, rigid part of the structure. The resulting

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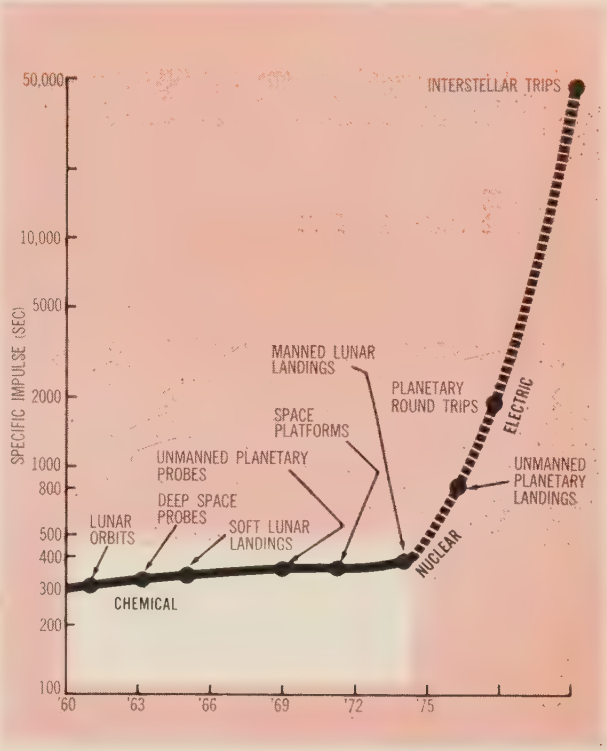


TIMETABLE for propulsion progress shows that for many years to come we will still have to rely on chemical propulsion.

Improvement of Specific Impulse

Propellants	Best Present I_{SP}[1] (sec)	Future I_{SP}[2] (sec)
LOX & hydrocarbon fuels	235	310
Fluorine & ammoniated fuels	290	400
Oxygen & hydrogen	300	410
Fluorine & hydrogen	340	450
Solids	250	310
Storable oxidizers (N_2O_4, ClF_3, etc.) & hydrazine	270	330

(1) At 300 psi chamber pressure and sea level expansion ratio.
(2) At 600 psia chamber pressure and 30:1 expansion ratio.

structure is unusually simple and can carry large payloads. Naturally such a structure must always be pressurized, or it will wrinkle and collapse.

• The rocket propellants themselves have in many cases been substituted for separately carried hydrogen peroxide as the supply for gas generators driving propellant pumps. Both weight and complexity are saved by eliminating the separate gas generator propellant system. With uncooled combustors, the propellant mixture for the gas generator is run very rich to insure long burning periods.

Plumbing for better combustion

• Advanced propellant flow valves give close control of propellant mixture ratio and pump speed and torque, and insure efficient combustion. These proportioning and ratio valves are connected through a servo loop to a sensor registering the chamber pressure, which gives a good indication of the combustion and thrust.

• By installing baffles and grids in the tanks, propellant sloshing has been controlled, which can cause serious perturbations in very large missiles.

• Stainless steel alloys stressed to more than 200,000 psi have sharply reduced the weight of solid thrust chambers. For solids, cases as thin as 1/16 in. have been made of these alloys. One problem with these alloys is that they are hard to weld and heat-treat.

• Through the use of segmented injectors and special valves, smooth throttling operation has been made possible for liquid rockets. (However, the cross-coupled electric and hydraulic circuits needed for "single-stick" control of rocket thrust are still highly complicated.)

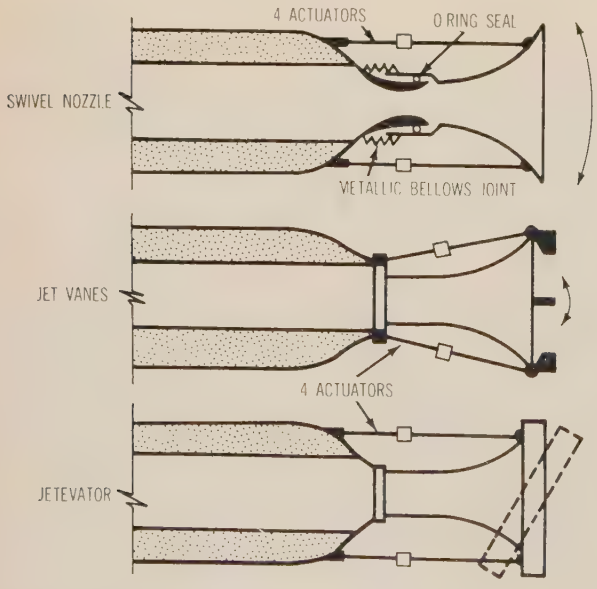
In all these areas, further improvements can be made, especially by increasing the reactivity of the propellants, the chamber pressure, and the nozzle expansion ratio (see *Table*). Other important improvements that can be foreseen are:

• *Plug Nozzles*—By turning the conventional Delaval nozzle "inside out", you get the plug nozzle, which is simply a solid cone that is pointed in the direction of the rocket exhaust and whose base is slightly smaller than that of the vehicle (*Fig. 4*). Around this base is arranged a ring of small combustion chambers of conventional design. The exhaust flames from these combustors are directed inwards onto and flow along the wall of the plug nozzle cone.

Thrust increase is made simple

The great advantage of the plug nozzle is that it makes it relatively simple to increase an engine's thrust —you merely increase the number of small combustor's around the nozzle's base. With a conventional nozzle, an entirely new configuration would have to be developed. Thrust vectoring is also made easier—you simply control the propellant flow to some of the combustors

• *Girder Structures*—So long as propellant tanks are part of the vehicle structure, they will have to be pressurized and therefore be made of expensive materials that are hard to work with. Furthermore, as tank sizes go up, there problems as well as others of structural design and handling become much worse. Designers



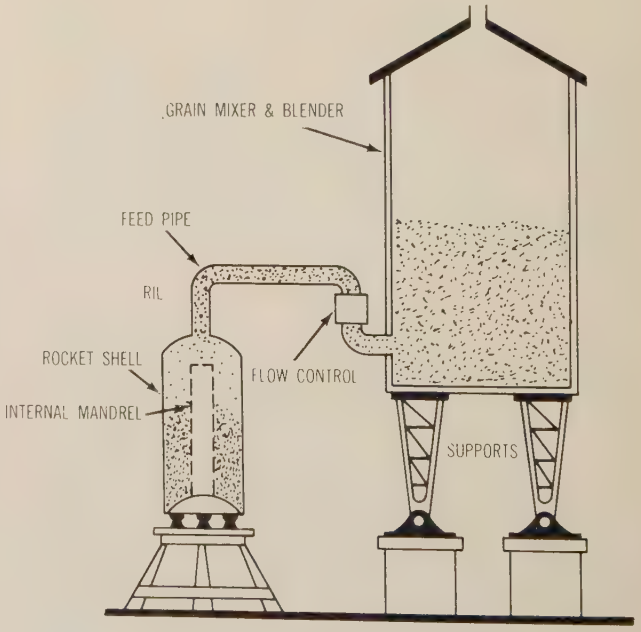


FIGURE 2: Three designs (left) for rocket thrust vector control. Right: An arrangement like this one could be used for on-site loading of solid rocket propellants. A hopper could be used instead of the feed pipe. The mandrel inside the rocket shell is withdrawn once loading is completed.

therefore are working on vehicles whose external structure consists of aluminum girders (*Fig. 4*). Tanks supported by such a structure could be made of cheap, low strength metals or even plastics, since they would not have to be highly stressed.

• *Bladder Pressurization for Liquids*—In this design, the pressurizing gas is not pumped directly into the propellant tank (to press down on the propellant from above) but rather into a bladder hung inside the tank (*Fig. 3*). As the gas inflates the bladder, outward pressure is exerted on the propellant from all directions. Such an arrangement is essential for space flight under free-fall conditions, when the gas may not remain above the propellant in conventionally pressurized tanks.

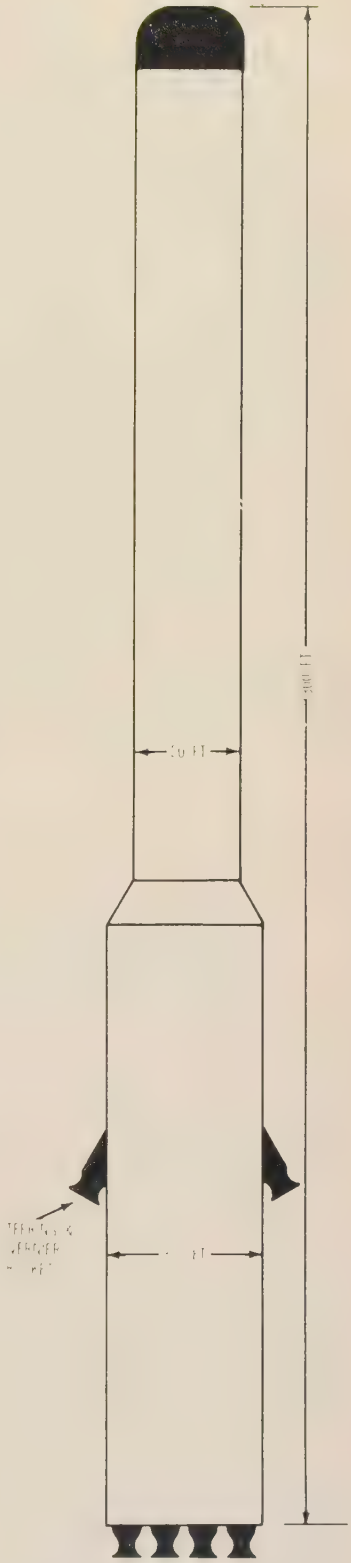
Jetevator ring erodes slowly

• *Thrust Vector Control for Solids*—For such control, a swivel nozzle, small jet vanes, or a jetevator ring may be used (*Fig. 2*). In the case of the jet vanes—which can be made of carbon or some refractory or metal—four are needed for pitch, yaw, and roll control. The jetevator ring has the advantage that it is exposed to the exhaust gases only when it is actually in operation. It therefore erodes more slowly than do jet vanes.

• *Thrust Modulation for Solids*—Either an ultrasonic "whistle" or vent valves can be used to change or control the thrust level of a rocket (*Fig. 3*). The sonic energy from the whistle, or driver, is expected to affect the propellant burning rate by interaction with the hot

more on next page

THE ULTIMATE in chemical propulsion might be a combination like this one of a monster booster burning LOX and JP to produce 8,000,000 lb thrust with upper stages using H_2 and O_2. A design of these dimensions might put a manned 100,000-lb payload into orbit.



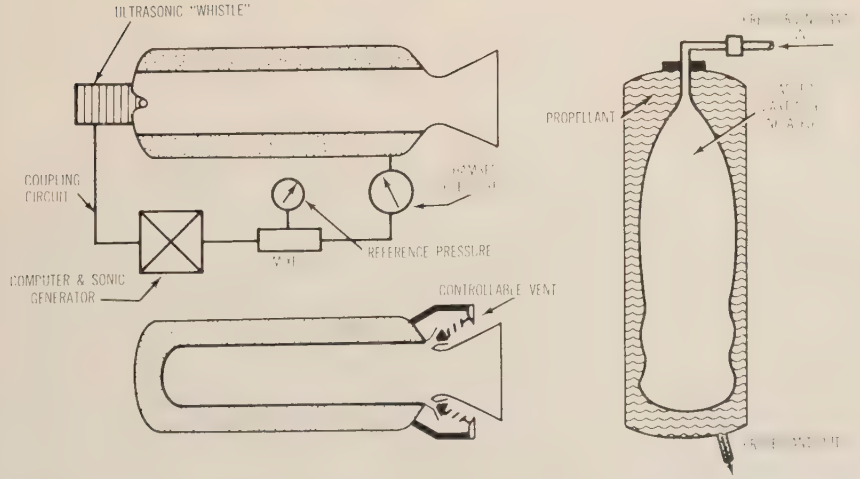


FIGURE 3: Thrust control of solid propellant rockets (left) may use either an ultrasonic "whistle", or driver, which modifies the propellant burning rate in the combustion chamber, or a poppet, or vent, valve. Center: Bladder pressurization of propellant tanks, which is essential for free-fall conditions.

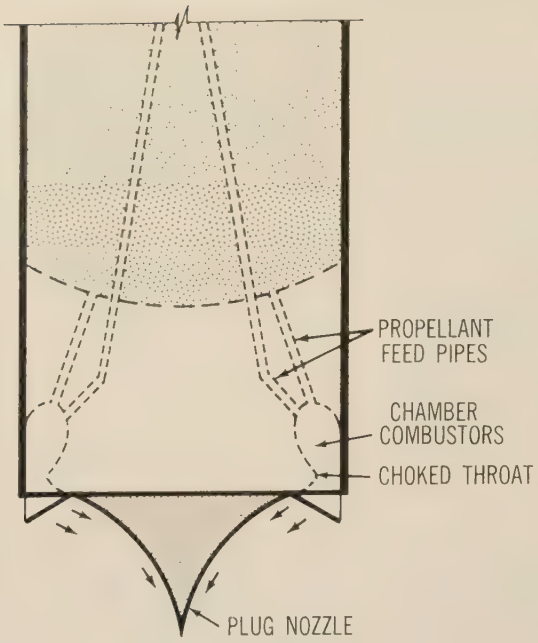
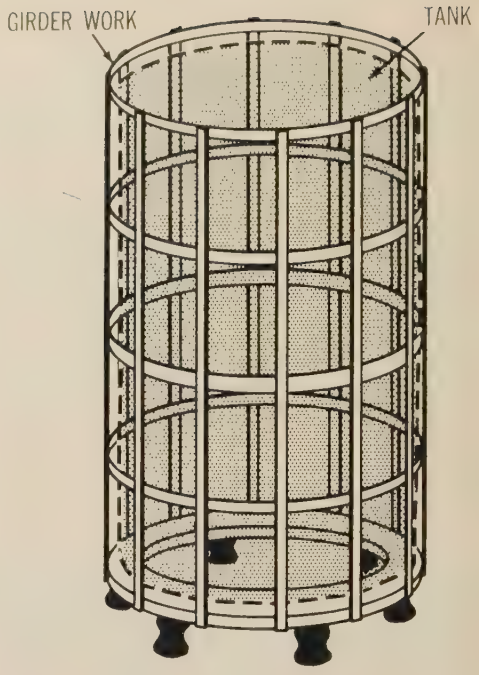
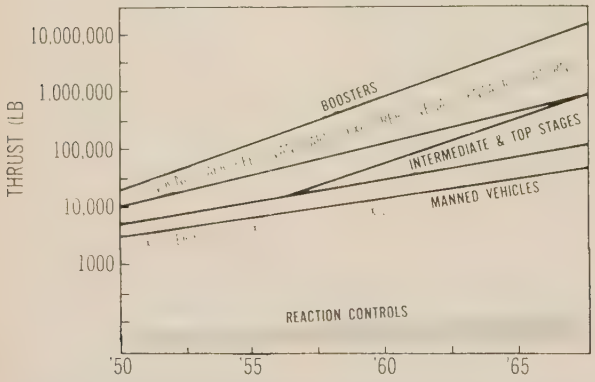
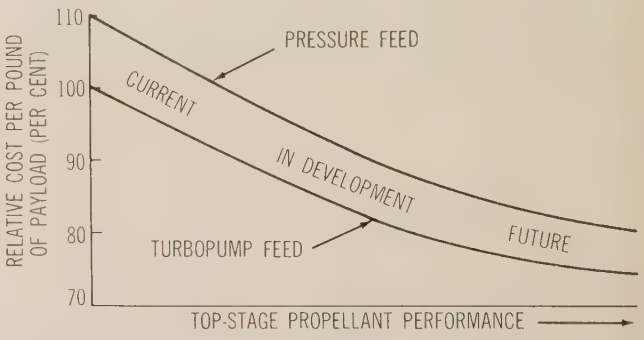


FIGURE 4: The plug nozzle (left), an inside-out" version of the conventional nozzle, provides a relatively simple method of increasing thrust. Right: With external aluminum girders forming the basic stage structure, the propellant tanks need not be highly stressed and can be made of ordinary low strength metals and possibly even of plastic. Such a design would save money and make fabrication easier.





THRUST IMPROVEMENT since 1950 has not yet outstripped the potential of chemical rockets.



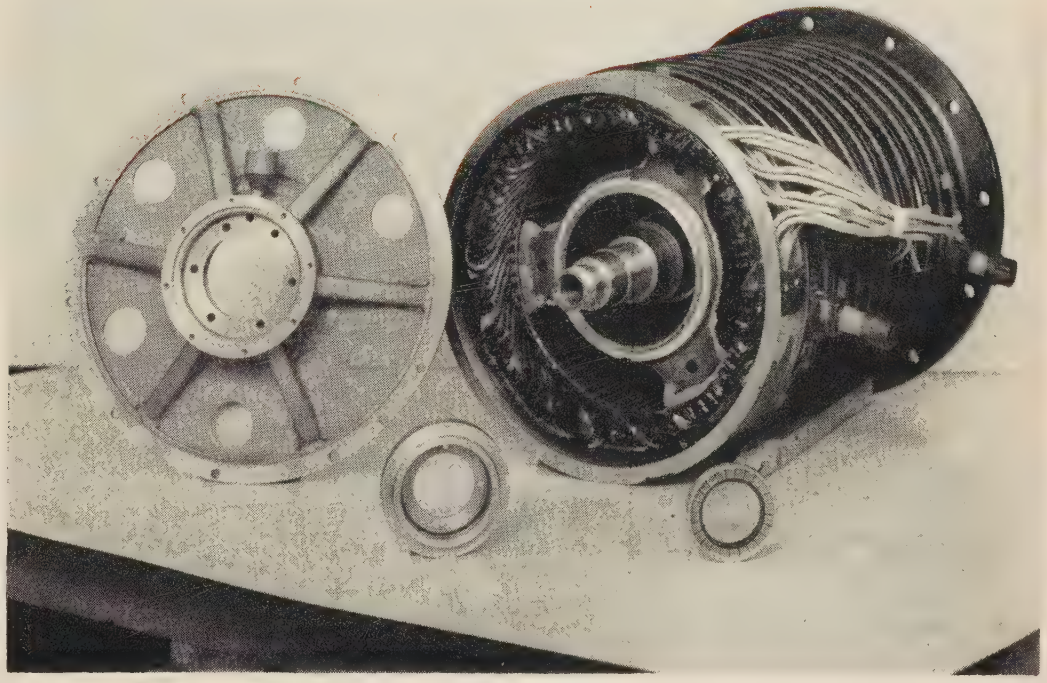
COST TRENDS of orbital missions as a function of propellant performance.

reactant gases in the combustion chamber. The heat-resistant, hydraulically actuated vent, or poppet, valves would simply be used to vent some of the propulsion combustion gases directly from the thrust chamber rather than through the nozzle.

• *Thrust Cutoff for Solids*—Large vents can be installed at either end of a combustion chamber (*Fig. 1*). When the frangible disks in these vents are explosively shattered, the chamber pressure quickly drops below the minimum value at which it can support combustion and the rocket stops. If the vents are installed at the end of the chamber opposite from the nozzle, both thrust and the forward force component are cut off within milliseconds.

• *On-Site Loading for Solids*—Many of the handling problems of big boosters will be eliminated once solids are mixed and blended on site and fed into the rocket on the launch stand through pipes or hoppers (*Fig. 2*). The curing of the propellant would take place within the rocket itself.

Rocket engines that incorporate all these improvements will meet the needs of many space missions, including advanced lunar flights and some planetary ones. These comparatively modest missions are all that we realistically can hope to tackle within the next 20 years. By the end of that period, chemical rockets will be powering tremendous vehicles with a thrust of several million pounds and will indeed have reached the limits of their potential. Then "exotic" propulsion will no longer be "extraneous".—End



ROTOR for an inductor-lundell design. The center section is nonmagnetic, so that the flux will not leak through the shaft.

Designing a generator

for 600-deg F operation

There are quite a few design possibilities for a high temperature generator that look good at first glance. On closer inspection, though, each turns out to have some fatal drawback. The thing to do, this article points out, is to take the good features of several designs and combine them in a new configuration.

by J. T. Bateman, AC Generator Engineer, DC Motor & Generator Dept., General Electric Co.*

HOW do you go about designing a generator for high temperature operation? Use a simple configuration and don't be afraid if it turns out to be rather unconventional. Here at GE, for instance, a 600-deg-F-ambient generator program (started in March 1958) eventually led us to a combination inductor and lundell machine.

In its basic form, a homopolar inductor's electromagnetic weight is 30 per cent higher than that of a lundell design at the ratings and speeds most important for aircraft applications. But the basic lundell generator has a high leakage flux in the rotor, which reduces transient performance. The trick is to combine the two designs so that their disadvantages are largely overcome.

* DC Motor & Generator Dept., 3001 E. Lake Road, Erie 1, Pa.

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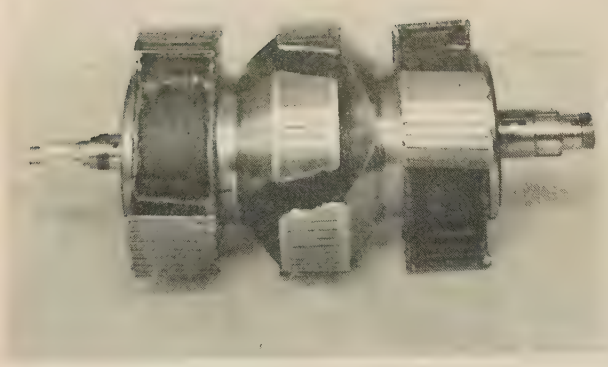
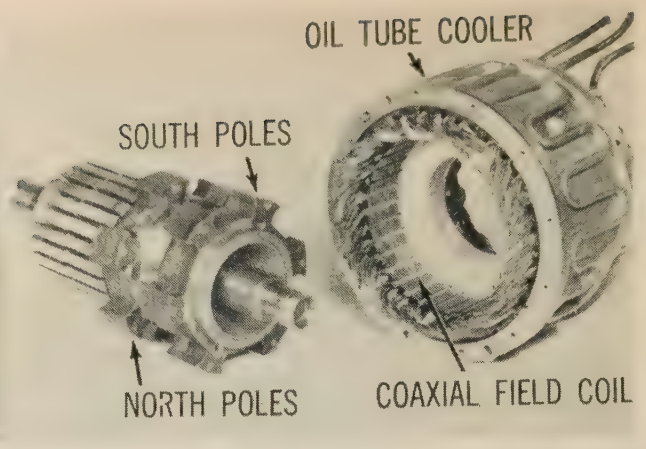


ASSEMBLY of a combination inductor-lundell rotor in an oil-cooled stator.



BRUSHLESS 30-V, 100-amp dc generator is used on a current high performance interceptor.

Our combination machine meets all the design objectives set up at the beginning of the development program:

- Use a minimum of parts, especially where high electric or mechanical stresses are concentrated.
- Remove all windings, rectifiers, and other electric parts from the rotor (to eliminate brushes, slip rings, and commutators).
- Use the mechanical strength of the electromagnetic iron parts to make the structure more rugged.
- Design the electromagnetic circuits so that rectifiers, capacitors, and other sensitive components can be moved to a more favorable environment if necessary.

Low weight was prime requirement

The foremost requirement, though, was a lightweight design. Most of the promising configurations we studied were heavier than conventional salient-pole, wound-rotor designs. Not that this was unexpected. Our goal really was to find the most reliable designs and then see what could be done about reducing the weight and improving performance through design refinement.

Our study centered about a double-ended, homopolar inductor configuration (*Fig. 1*). In a conventional salient-pole synchronous generator, the alternately north and south magnetic poles of the rotor are induced by dc field windings placed around each pole piece. Field current from a stationary source must be supplied to the rotating windings through some sort of sliding contact or brush arrangement. The way to get around this one is to convert the conventional generator into a homopolar inductor machine.

You lengthen the body and stator but use the same pole pieces, rearranged so that the north poles are all placed at one end and the south poles at the other. The angular relationship of the poles is left unchanged.

All of the magnetic flux that passes from the north to the south poles flows through the center of the shaft. A single coaxial field coil around the rotor shaft at this central station is enough to link the flux and supply the necessary excitation. The coil does not have to rotate, so it can be fixed in the stator—and you've eliminated the brush and contact problem.

The flux must travel axially both in the center of the rotor and outside the stator core. Solid steel paths are provided in both cases. One of the benefits of a common link is that the coaxial coil has to supply only as many ampere turns as do two of the separate coils in a conventional salient-pole design. In the case of a six-pole generator, you save a lot of excitation power in this way.

Offhand it would seem that the inductor machine would have to be twice as large as its conventional counterpart. It doesn't. The inductor is usually heavier, but the typical increase is only about 60 per cent. In some applications, the lower excitation power requirements and the elimination of current collectors will actually result in a reduced system weight.

The weight disadvantage of the homopolar inductor generator is largely explained by the fact that the north and south poles are at opposite ends of the rotor. No part of the stator sees a full north-to-south variation of flux. With half-wave flux, the stator iron is used to only half its capacity, and the machine must be heavy.

The lundell generator overcomes this disadvantage. Its rotor configuration presents alternate north and south poles to a single stator and uses a coaxial field coil. Instead of being remotely positioned at opposite ends of the rotor, the north and south poles are extended from each end toward the center and slightly beyond each other. This design presents an array of alternate north and south poles to the stator and provides for a fullwave flux variation. The result is optimum electromagnetic stator weight.

Two secondary, or parasitic, air gaps are always required to complete the rotor flux circuit and yet allow the use of a stationary coil. In the configuration of *Figure 2*, flux travels along the frame and crosses a secondary air gap into the north pole end of the rotor. It then travels out along the cantilevered north pole fingers, emerges from the north pole faces, and crosses the main air gap into the stator.

The flux follows the same paths in the stator as it does in a conventional salient-pole generator. Emerging from the stator, it crosses the main air gap into the south poles and finally a secondary air gap into the frame. As in the inductor generator, a single coaxial field coil excites the entire flux path, regardless of the number of poles.

Brushless lundell machines will generally be 30 per cent heavier in electromagnetic weight than conven-

tional generators. A lundell rotor tends to be a very closely intertwined, three-dimensional configuration in which the leakage between north and south poles is about four times as high as in conventional generator designs. Because of this high leakage, the rotor iron must be increased if it is to accommodate the leakage flux. The result is a heavier rotor.

If you design a short rotor flux circuit, the rotor leakage will be high because the rotor parts are crowded together. If you design a long rotor flux circuit (in an effort to separate the parts and so reduce leakage and weight), the rotor will still be heavy—because of the length of the flux path.

High rotor leakage also reduces the generator's transient performance. The leakage flux represents stored energy that tends to cause voltage overshoots when the load is removed. Rotor leakage reactance also increases the open-circuit time constant of the generator.

All these problems largely disappear when you combine the inductor and lundell generators. Suppose you start out with two homopolar inductor generators located side by side (*Fig. 3*). Each is complete—double-ended rotor, two stator sections, coaxial coil, and frame. Now alter the rotors of each machine slightly so that the inner sets of poles fit together in a lundele manner, and join them. With one stroke, you have eliminated one entire stator section as well as a significant number of stator conductors and conductor end turns.

In the combined design, the two parasitic air gaps of the lundell generator are replaced by working gaps, with inductor power generated at each end of the machine. The lundell pole-to-pole leakage still is there and still is greater than the leakage in conventional machines. However, the pole configurations naturally extend in opposite directions to minimize leakage without necessarily increasing the length and weight of the rotor iron.

Even more important is that the effect of the lundell leakage on overall generator performance is drastically reduced. The flux leaking between the lundell poles generates no voltage in the center stator section. What it does is generate useful voltage as it completes the circuit through one inductor generator, crosses the frame, and returns through the inductor section at the other end.

The total effect of the lundell leakage as seen at the terminals of the inductor-lundell generator is less than half of that of the original lundell design. This reduction is large enough to make the performance under transient conditions quite acceptable.

Improvement must be paid for

Of course you don't get the improved performance and reduced weight of the inductor-lundell generator for nothing—this configuration is very complex and difficult to design and analyze. For example, the size of the inductor portion depends on the leakage between the poles in the lundell sections—and this leakage is affected by the size of the inductor portion.

You have so many parameters to play around with that you need a computer to find the optimum values. Our design work on an IBM 650 shows that inductor-lundell electromagnetic weights are generally less than those of the basic homopolar inductor and lundell configurations for conventional speeds, frequencies, and ratings. For many less common speeds, ratings, and duty cycles, which are nevertheless specified from time to time for aircraft applications, the combination design may turn out to be lighter than conventional salient-pole unit.

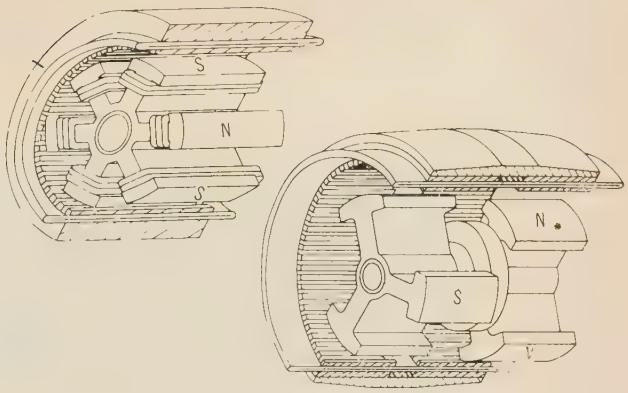


FIGURE 1: Comparison of a conventional salient-pole generator (left) and a homopolar inductor generator.

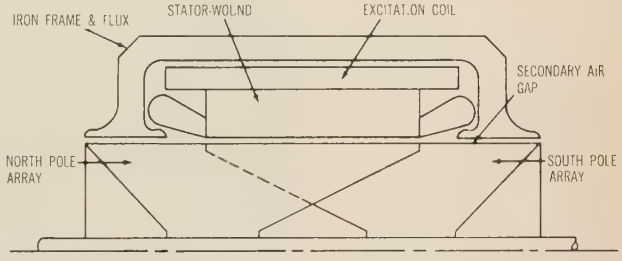


FIGURE 2: One of many lundell generator design possibilities, with the rotor flux path completed behind the stator.

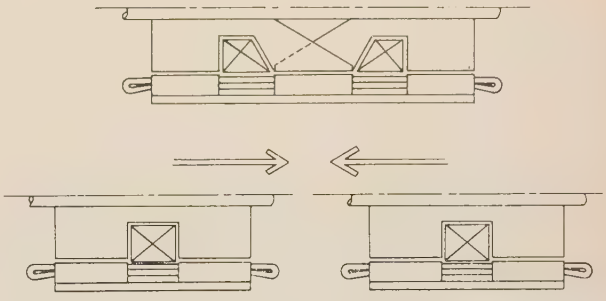
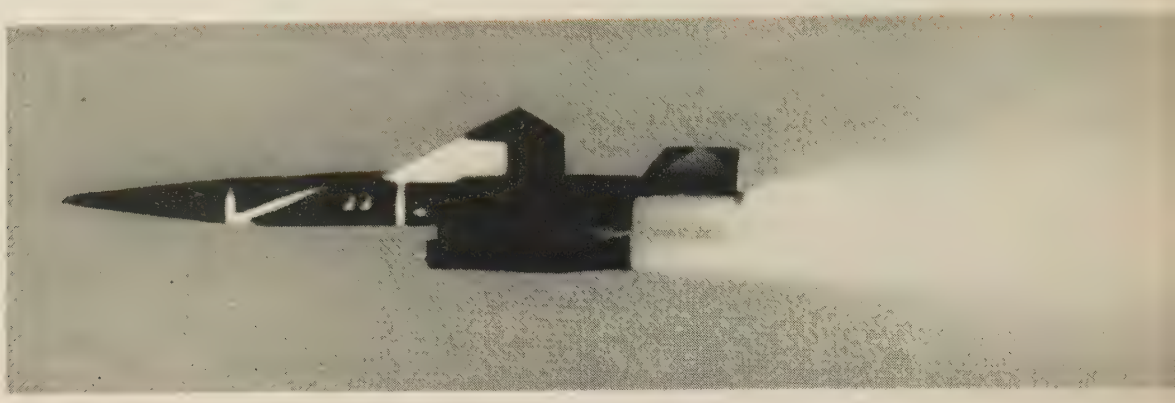


FIGURE 3: Combination of two inductor generators (top) into a single inductor-lundell configuration (bottom) reduces weight and improves performance.

Results of both analytical work and testing have shown that the electric characteristics of inductor-lundell machines are comparable to those of conventional generators. For the 600-deg F program, the generator characteristics, voltage balance under unbalanced loads, waveform, efficiency, and short-circuit capabilities have all been better than the spec requirements.—End



IM-99A BOMARC just after leveling out at cruise altitude. The missile has an estimated cruise speed of Mach 3-4.

Boeing stresses maneuverability in

Bomarc evolution

The long history of the Bomarc pretty much is the history of what we have learned about the requirements and problems of interceptor missiles. Here's an analysis of the many transformations that the Boeing bird went through and of the operational vehicles that emerged in the end.

by Irwin Stambler,
Associate Editor

WHEN THE FIRST IM-99A Bomarc interceptor missile reached operational status a few months ago, a series of missile studies that goes back all the way to 1945 was brought to a successful completion. Both the operational Bomarc and the improved -B version, which is to become operational next year, are lineal descendants of Boeing's Gapa (Ground-to-air pilotless aircraft), developed and flown in a variety of configurations between 1945 and 1949. Wing shapes, control mechanisms, ramjets, and the like were tried out in this program.

The transitions from Gapa to Bomarc occurred in 1949, when the Pentagon decided to assign all missile work for ranges under 100 miles to the Army. As an Air Force project, the below-100-miles Gapa no longer had a future. But rather than waste the experience it had gained, Boeing looked for some way of applying it to longer range missions. It discovered that the University of Michigan had a research project underway on

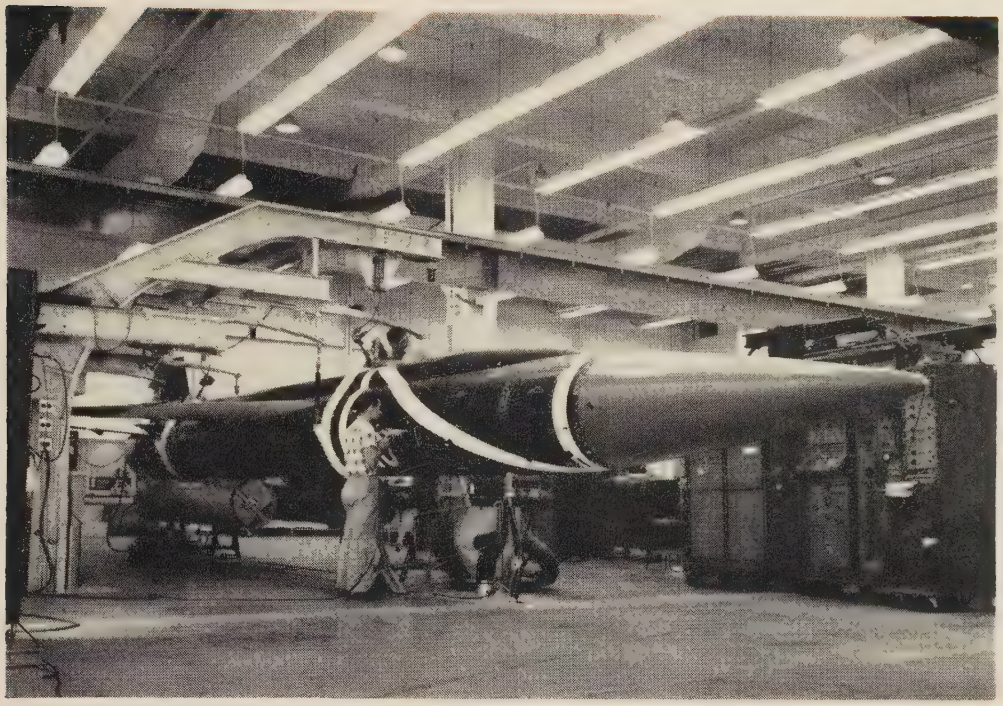
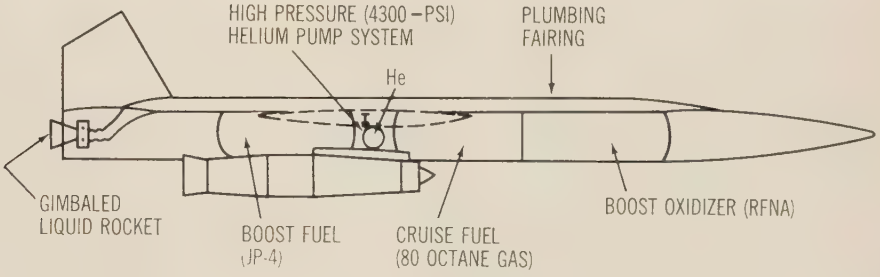


FIGURE 1: Nine-foot-long fiberglass radome of Bomarc (left) is made by the Philbrick-Strickland method of machine-winding glass filaments in criss-cross around a mandrel while stress is applied. The result, Boeing reports is resin bonding to physical tolerances of ±0.002 in. throughout the structure. Below: Fuel tank arrangement of the IM-99A.



the equations for guiding a vehicle into an intercept. Boeing and Michigan pooled their findings and decided to work on a missile that would be guided into the general intercept area from the ground and then pass to the control of airborne homing. (The name "Bomarc" symbolizes their collaboration—it combines *Bo*eing and *M*ichigan *A*eronautical *R*esearch *C*enter.)

A Bomarc flight, Boeing engineers states, is divided into three phases (*Fig. 3*). For boost and climb, the missile is under automatic, programed control. At first, control is achieved by deflection of the gimbaled rocket nozzle; at near-transonic speed, the aerodynamic surfaces take over. The missile's booster rocket burns out at about 30,000 ft, by which time the two Marquardt ramjets have reached full power.

Several thousand feet before cruise altitude is reached, altitude control is taken over by a static-pressure-sensing device. At the same time, ground control assumes command for the second, or cruise, phase of flight (except for altitude). It sends out the heading angle and also signals to tell the missile how soon it is to start its dive (or climb) and are based on a precomputed estimate of the intercept of the target. The missile stores these TRUD (*T*ime *R*emaining *U*ntil *D*ive) commands and all others it gets from the ground—as well as any changes—throughout the cruise phase until TRUD equals zero. If ground station is disrupted, the bird will keep going on the last command it received. At zero, TRUD goes into the commanded dive or "zoom".

The commands from the ground also include target-seeker (T-S) sweep angles that define the cone in which the missile should look for its target. When the target is picked up by the missile, the third and last flight phase begins, with the bird completely under the control of the target seeker, which is locked onto the target.

The first and last phases of flight, Boeing notes, are automatic and can't be changed from the ground, but

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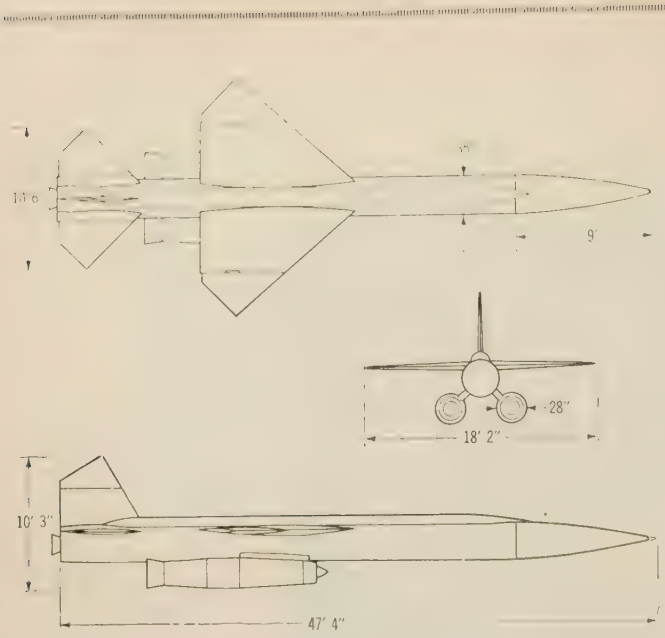


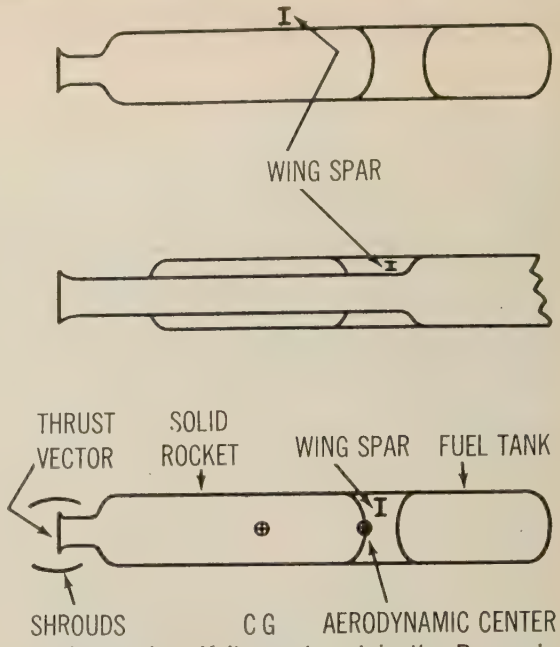


FIGURE 2: The first operational version of the Bomarc, the IM-99A weighs about 5,000 lb. It uses an Aerojet-General LR-59-AG-13 liquid rocket booster and two Marquardt RJ43-MA-3 ramjets. The thrust of each ramjet is estimated at 10,000 lb. Reportedly the missile can cruise at 60,-80,000 ft. Right: The wing-CG relationship was one of the major design problems of the solid rocket IM-99B version. If it was to retain the Bomarc's structural simplicity, Boeing was limited in the placement of the wing. Three of the many configurations configurations considered by Boeing are shown here (with the relationship of CG and aerodynamic center as it would exist at launch). The bottom configuration was finally chosen.

Gapa vs Bomarc

	Gapa	Bomarc
Range (nm)	>1000 nm	200-450
Pitch control	movable wing	elevator
Roll control	very small aileron	ailerons
Other characteristics	fixed tail surface, no rudder; beam rider, intended for homing radar	fixed wing; yaw control by rudder; active seeker for terminal phase

there's a lot of flexibility in the cruise phase. In one case, for instance, a missile on the way to one target was commanded half-way through the cruise phase to change targets—and it did. The system is also flexible enough, SPACE/AERONAUTICS was told, to send two simultaneously launched missiles to two closely spaced targets or in two completely different directions.

The wing and tail planforms of the Bomarc are identical. This feature was taken over from the Gapa. However, the Gapa had a fixed tail and a movable wing. The latter was used to get very fast response to steering commands. But with the tail fixed, the Gapa couldn't properly damp its angular oscillations. On the Bomarc, Boeing therefore went to a fixed wing with ailerons and a tail control system that can be used either to pitch the vehicle or apply damping.

The Bomarc turns by rolling and pitching. For the terminal phase, it would have been more convenient to have another set of wings at right angles to the main ones, which could have turned the vehicle by pitch or yaw. However, as the cruise phase is longest and involves load factors of less than 1-1.1 g, Boeing points out, the drag penalty of an extra pair of wings carried just for the terminal phase would have been excessive. The Boeing designers decided to solve their problem by making their vehicle highly maneuverable during the last phase. The result is a winged vehicle that flies like an airplane. This approach also avoided the weight penalty of an interdigited system, which would have required a larger booster, and other heavy equipment.

The full-chord tip surfaces on the wing were placed as far out as possible to get high roll acceleration. This configuration also made it easier to predict the forces on the tips since the surfaces are exposed to free air rather than the wing wake. A triangular shape was chosen to keep the center of load near the maximum-thickness point of the wing. With tip surfaces, Boeing found, it was also able to minimize actuator requirements, hinge moments, etc.

The Bomarc's elevators are completely movable. The smaller rudder is used mainly to damp oscillations.

The wind and tail planforms and their spacing were chosen to give very fast response, particularly in the terminal phase. This consideration limited the sweepback—so much wing area was required that a large

sweepback would have decreased the distance to the tail and so led to control problems. The planforms were selected so as to make a completely separate tail feasible. Trailing-edge surfaces, Bomarc engineers note, would not have been as efficient—because of lower supersonic effectiveness, difficulties in hinging, the need for more hydraulic power, etc.

The Gapa vehicles used external boosters. For the Bomarc, an integral booster was chosen, primarily to prevent any damage to people or property on the ground by a jettisoned first stage. As it turned out, the internal booster also provided size, weight, and handling advantages, Boeing states.

Liquid rocket simplified balancing

A liquid rocket was chosen for the "A" version partly because of propulsion state-of-the-art advantages at the time the Bomarc design was started and partly so that two fuel tanks could be used to solve balancing problems (*Fig. 1*). With the tanks forming the vehicle's body, a very compact design is made possible.

The rocket nozzle is gimbaled for control during the boost phase when the aerodynamic surfaces are ineffective. The Bomarc's cylindrical body shape and long, thin nose were selected primarily for manufacturing reasons. A simple fuel expulsion system is located between the aft boost fuel tank and the central cruise engine because the Bomarc must fly long distances with good efficiency. A ramjet is six times as efficient as a rocket, Boeing states, since it doesn't have to carry its own oxidizer. It also lets the vehicle fly at constant speed, which simplifies the command computations. Maximum speed for the two Bomarc versions has been estimated to vary from Mach 3 to Mach 4.

The Boeing designers would have preferred a single ramjet mounter under the missile's body. Computations showed that a 36-in.-diameter engine would be needed for this installation. Unfortunately, at the time only 12-in.-diameter units had been developed, and facilities were lacking to test any as large as 36 in. in diameter. As a compromise Boeing therefore decided to use two 28-in.-diameter engines.

At first, Boeing planned to put the two ramjets under the wings. However, with this installation more roll power would have been needed to get the desired fast response. Studies also indicated that under the wing the engines might cause dynamic instability. In the end Boeing decided to put the ramjets on the body.

This installation also keeps the fuel lines short and, by separating engines and body, makes it possible to change the engine design without any body changes. It further simplified the flight-testing since body and ramjets could be tested separately (see *S/A, "X-7 Tests Speeded Bomarc Ramjet Development," Sept. '58, p. 88*). Finally, the ramjet inlets on the Bomarc are essentially in free air. On the other hand, the placement of the ramjet ruled out the use of vertical tail under the body, which had been a feature of the early Bomarc designs.

One of the problems Boeing faced was that the ramjets are relatively large compared with the missile body and have a decided effect on the overall aerodynamics. Air passing over them produces local high pressure regions on the wing. Careful study was also needed because of close coupling of wing and tail surfaces (which usually isn't a problem on aircraft designs).

Boeing's prime aims in going from the "A" to the "B" version of the Bomarc were to (1) get substantially better range, (2) carry an improved target seeker, and (3) simplify the ground maintenance system. It was because of the last of these aims that the company went to a solid boost rocket on the "B".

The main problem in going to a solid rocket was the CG location. The reason for this is that, with the CG far aft on a winged vehicle, small changes in attitude cause large changes in disturbing moment.

Basically Boeing wanted to have the CG somewhere near the wing center. Structural simplicity was another basic requirement, and limited the range of acceptable wing locations (*Fig. 2*). Boeing had a problem because the Bomarc's CG is aft on the ground and forward after booster burnout. *Figure 2* also shows the compromise solution that was chosen in the end.

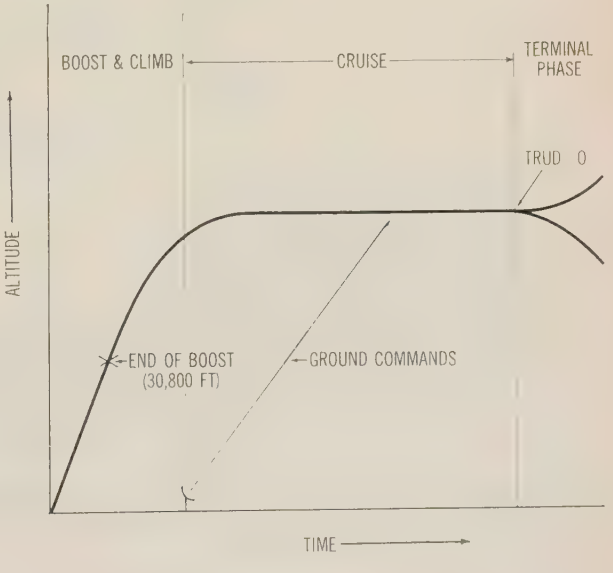
The problem of disturbing moment was solved by using a thrust-vectoring jetevator vane system at the nozzle. When the vehicle reached a speed high enough for the elevators to become effective, jetavator shrouds are locked in neutral position.

After the boost phase, the "B" normally has no severe stability problems, since the CG moves ahead of the aerodynamic center. In the terminal phase, the CG moves back to roughly neutral stability.

The "B" shows no basic external changes except that its body is a little shorter and its wing and tail surfaces are slightly farther apart. It has improved guidance and can fly at higher altitudes, thanks to the more powerful Marquardt RJ43-MA-9 cruise ramjets.

The speed of the "B" probably is around Mach 4—in X-7 tests, the MA-7 ramjet has reached Mach 4 and altitudes over 100,000 ft.—End

FIGURE 3: During boost and climb, the Bomarc is automatically controlled by a timer. Heading changes are programmed in as a function of time. Several thousand feet below cruise altitude a static-pressure-sensing device takes over altitude control. At the same time, the missile passes to the control of the ground command system (except for altitude commands). The ground commands include heading angle, TRUD, dive angle, and azimuth and elevation T-S angles.



Sergeant GSE

sets pattern for IRBM mobility

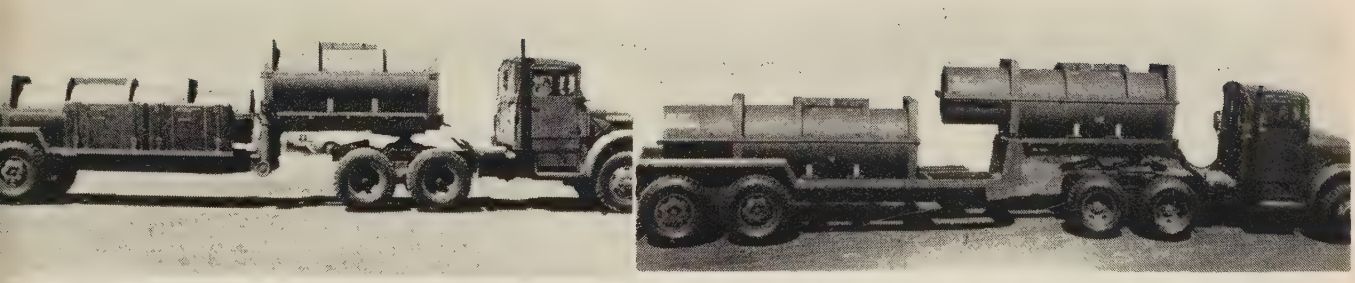
What happens when a missile all along is designed to GSE requirements? Oddly enough, it's the GSE that takes unconventional form under such a setup, but for all that the needs of practical operation are met.

by Victor de Biasi, Associate Editor

THE DEVELOPMENT of the Sergeant's ground support equipment (GSE) was started at the same time as that of the Army tactical missile itself. Naturally, design details had to wait on the final missile configuration. But the basic missile at all times was designed to the problems of field support and operation. The result: an unconventional but highly practical GSE system.

Jet Propulsion Lab did the original prototype development work on both the missile and its GSE, except for the field maintenance test station. Sperry-Utah Engineering Lab in Salt Lake City did the prototype production and qualification testing. Follow-up en-

EMPLACED LAUNCHER is self-loading. An electric trolley hoist system inside the boom makes it possible to pick up the missile sections separately and attach them to the boom and each other.



TWO CONTAINER vehicles are needed—one to transport the engine and guidance sections (left) and the other for the two warhead sections. The fin containers can be strapped to either vehicle.

gineering development and redesign were done jointly by JPL and Sperry.

The Sergeant is a solid propellant ballistic missile with a reported range of 150-200 miles. It weighs about 10,000 lb, is 34 feet long and 2.6 ft in diameter, and has a cruciform tail with a span of 5.9 feet. The GSO part of the weapon system, designed for operation in adverse terrain and under combat conditions, consists of the following major equipment:

- in a launching station, which combines loading, checkout, countdown, erecting, launching, and firing functions:
- an organizational maintenance test station used near the front lines to check out and maintain on an assembly level the missile's warhead, guidance, and tail fin sections, which are shipped to the launching station in separate containers;
- a field maintenance test station used well behind the lines to repair system assemblies on a replaceable-subassembly level;
- two transport vehicles used to bring up new missile sections to the launching station and to return defective units to the maintenance test stations.

One of the basic contributions JPL made to the

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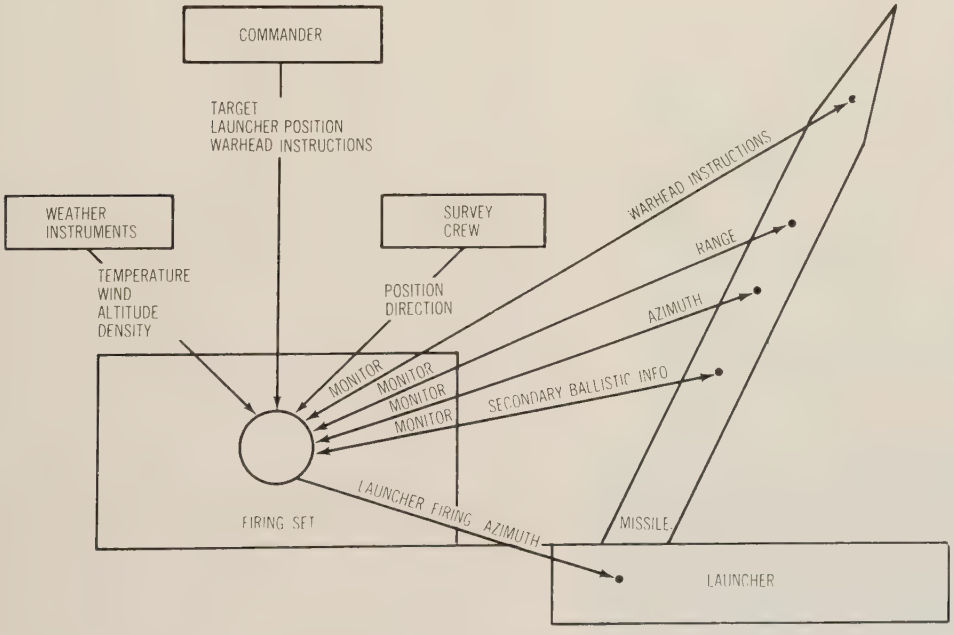
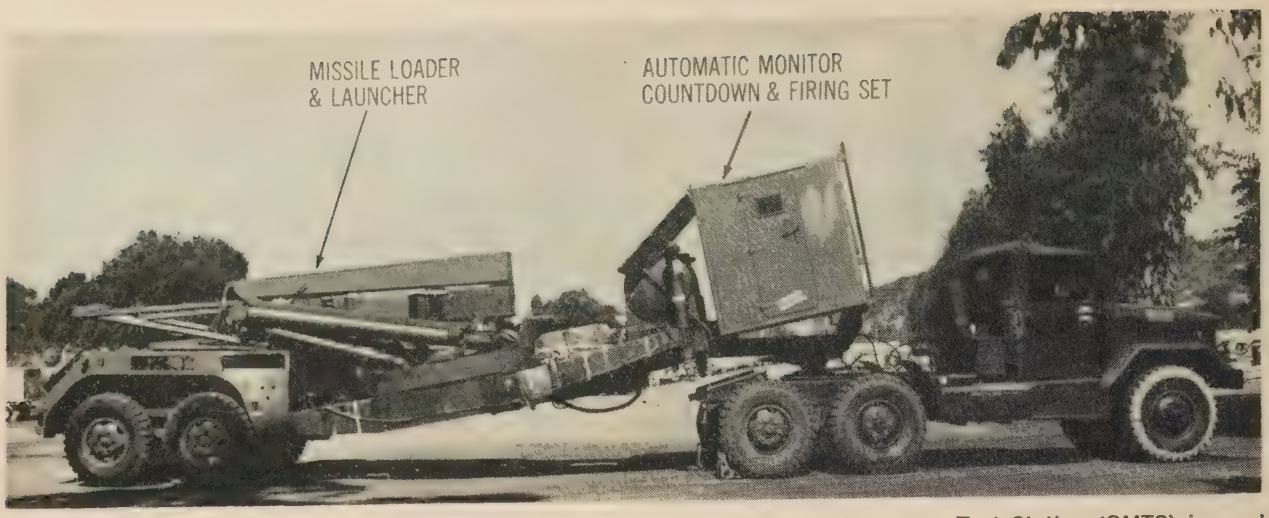


FIRING SET mounted on the launcher serves as a data flow clearance center to arm, instruct, and monitor the missile and launcher in preparation for firing.



OPERATIONAL GSE for Sergeant (left) consists of this launching station, two mobile maintenance test stations, and two missile container transport vehicles. Right: Organizational Maintenance Test Station (OMTS) is used near the front area to check out missile sections to the plug-in assembly level before they are sent to the

GSE design was the development of an expandable parallelogram structure to support the assembled missile for launching. Later the design was improved by making the launcher-erector self-loading and by mechanizing the azimuth orientation system. In the prototype design, the crew manually rotated the missile to its firing azimuth and elevation.

Solenoid valve for orientation

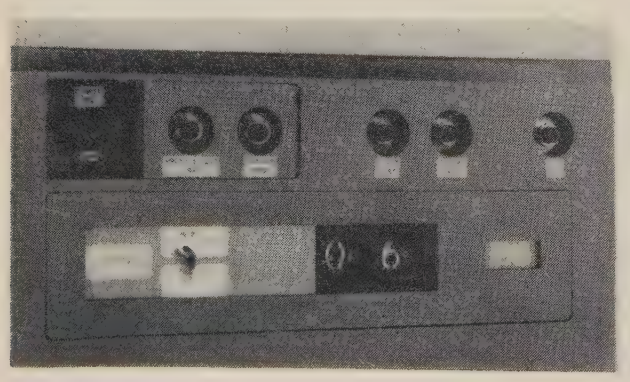
The hydraulically powered orientation system is controlled by a cam-actuated solenoid valve. A launching begins when one of the crew is given the firing azimuth received at the firing station. He goes to the launching ring, sets the movable cam on the calibrated fixed ring to that azimuth, and turns the slewing control to make the azimuth turret travel through the shortest distance from zero to the firing azimuth. Automatic controls do the rest.

A position impulse signal from the firing set (also part of the launching station) actuates the elevation solenoid valve, which starts raising the missile towards the vertical. At some predetermined elevation between the horizontal and the near-vertical firing position, an attitude-sensitive switch closes to cut off the hydraulic elevation circuit. When that happens, the azimuth solenoid is actuated and starts rotating the missile towards its firing azimuth.

Cams on the turret slewing ring control acceleration and deceleration in azimuth. When the drive is first energized, the fixed cam holds the flow regulator nearly closed, so that the system starts rotating slowly. As the moving turret clears the cam, the flow regulator opens fully to bring the angular velocity up to the maximum slewing speed. When the missile is within 15 deg of the firing azimuth, the movable, or adjustable, cam gradually closes the flow regulator to decelerate the turret and bring it to a smooth stop.

As the missile reaches its firing azimuth, a stop on the "downhill" side of the cam actuates a limit microswitch, which de-energizes the aximuth solenoid valve. The turret is now locked at the firing azimuth. At the same time, the microswitch energizes the elevation solenoid valve to complete the elevation cycle.

AUTOMATIC control panel in the FMTS is used to check out subassembly operation.

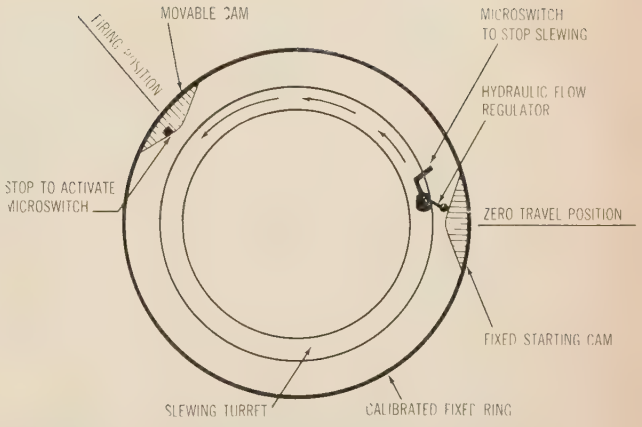


Erector members in tensile stress

With its unique parallelogram structure, the Sergeant launcher weighs only 60 per cent more than the missile itself—yet it is self-loading and erecting. The trick is that the structural members of the erector are placed under mainly tensile stresses throughout the launching cycle.

The parallelogram is expanded, or erected, by the extension of hydraulic jacks. The boom, normally folded back for traveling, is unfolded for loading and then folded again back in preparation for erection and launching. An electric trolley hoist inside the hollow boom picks up the sections of the missile, which are

launching station. The field maintenance test station (FMTS) looks quite similar but is equipped to repair assemblies at the plug-in subassembly level.



MECHANICS of the azimuth position control.

attached by lugs to the boom and then assembled to each other. First comes the rocket motor section, then the guidance and control section, and then the warhead. The four fins are separately attached after the missile is assembled on the boom.

Once loaded, the missile is checked out by the firing set. In the original design, there was only one firing set with spare replacement parts to take care of any failure. The production version includes a redundant operating side. Now, in the event of a failure, the stand-by can be switched into operation within minutes. The "fail" side can then be self-tested and repaired.

Firing set can trace faults

The firing set is used for automatic countdown and monitoring as well as for setting in the target co-ordinates. If it detects any out-of-tolerance condition in the missile, the set can trace the fault to the proper missile section. The section is then replaced and the defective unit sent to the mobile test stations.

All repairs in the field are made by replacing plug-in assemblies or subassemblies. The organizational maintenance test station (OMTS) is equipped to check major assemblies by tracing failures on an assembly level. The field maintenance test station (FMTS) is equipped to do the same work on assemblies to a subassembly level. Subassembly failures are returned to the factory.

The test equipment for both test stations is packaged in modules much as is the missile itself. Each major function is housed in a separately installed plug-in package, or assembly. In turn, each assembly is further divided into easily removable and replaceable plug-in subassemblies. Any failure detected by a self-check can be remedied by plugging in a factory-tested spare.

Testing in both the OMTS and FMTS is based on the premise that all electric measurements can be

more on next page

PIN-JOINTED PARALLELOGRAM launcher design makes it possible to get away with a very light structure and small erecting forces. Extension or retraction of the two hydraulic jacks that form the diagonal collapses or expands the parallelogram to erect or lower the missile. The structure folds back (to the left) in the stowed position.

reduced to two basic quantities: voltage and time.

Sampled measurements are processed (demodulated, amplified, attenuated, delayed) so that the waveform and magnitude can be compared with reference and stimuli generator standards in the test equipment.

Voltage dividers provide input signals to units under test while supplying high and low tolerance voltages to a comparator. Any voltage from eight volts to one millivolt can be supplied in one-millivolt steps with an accuracy of better than 0.05 per cent.

According to Sperry, the reference voltage network is unusual in its simplicity. It uses a Wheatstone bridge coupled with zener diodes to put out a standard of eight volts ±0.4 mv. The temperature-sensitive elements of the circuit are housed in a controlled oven to ensure stability.

Components were carefully chosen

Because of its judiciously selected components, says Sperry, the circuit is virtually insensitive to variations in input voltage. Since the reference voltage works into a fixed voltage divider, making the load a constant, you only have to compensate for the loading of the comparator and the input circuit of the unit under test.

A time generator furnishes the base and control for all timing operations. The time base is a one-kilocycle transistorized oscillator accurate to 0.001 per cent. The time generator itself is accurate to one millisecond and has a repeatability of five milliseconds.

All testing is done automatically by means of a program stored on punched tape. Through multiple stepping switches, the program selects the assembly terminals to be tested, the tolerance and power voltages, and the external subassembly test loads. All the operator has to do is connect the assembly to be tested, set in the assembly code number on the control panel, and press the "begin" button.

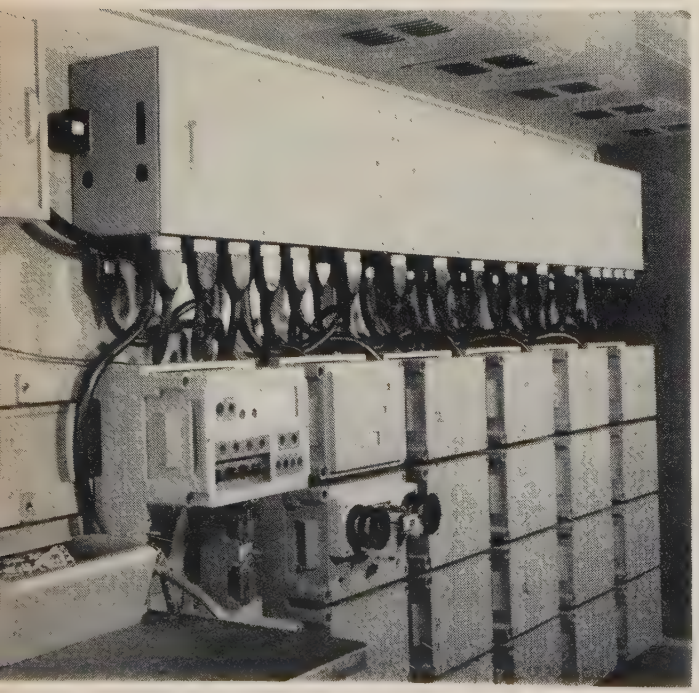
The test equipment first identifies the assembly by comparing the value of a resistor in the missile chassis with that of a resistor in the tester. If the two do not match, the test never gets started. Instead, a "no-go" light signals a chassis reject.

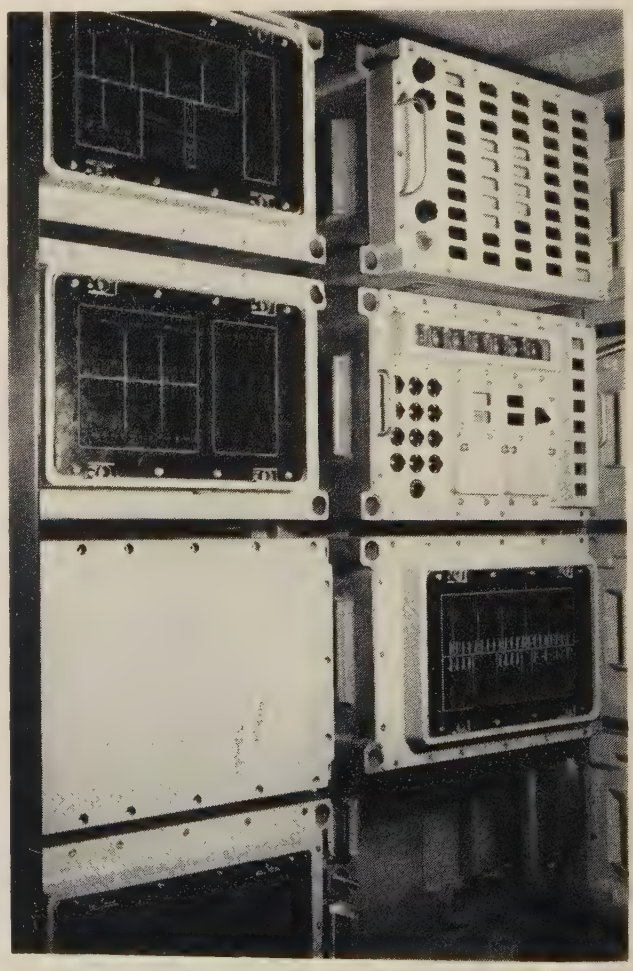
Self-check starts test sequence

Once the chassis is identified, the test equipment runs through a self-check, a power interlock check, and a series of subassembly tests. As each test is successfully completed, the tape reader receives a command to go on to the next test. So long as performance is satisfactory, this procedure is continued until the entire test sequence is completed.

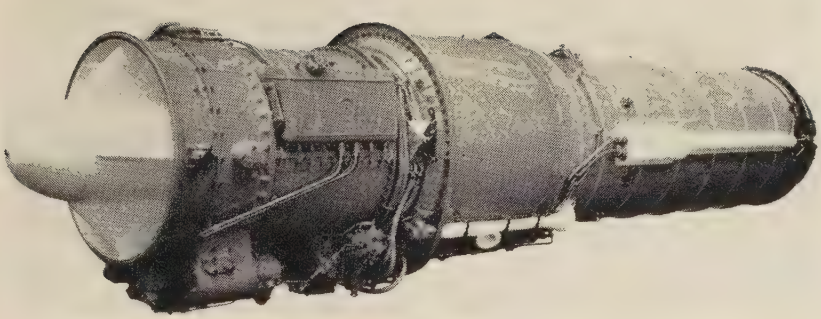
Faults show up as "no-go" light signals and are pin-pointed by a numerical indication of the defective subassembly. This subassembly—or, if you're at the OMTS, the assembly to which it belongs—is then replaced, and the test is continued.—End

TEST EQUIPMENT in the FMTS consists of 23 separate wall rack units. The gross weight of the loaded trailer is less than 16,000 lb.





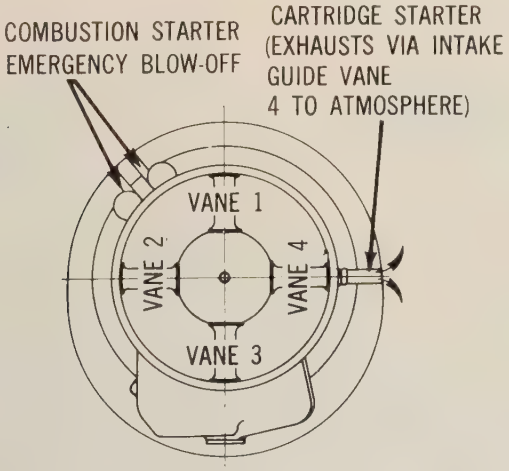
DIGITAL COMPUTER portion of the firing set

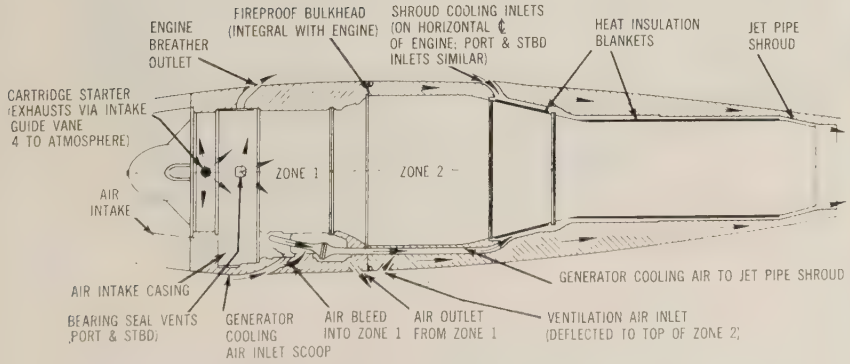


ORPHEUS-B-Or 12SR has 8170 lb thrust, was designed to meet requirements of advanced strike fighters. Orpheus 803 powers Fiat G91 lightweight strike fighter.

Orpheus 803 General Specifications

Max thrust	5000	lb
Maximum continuous thrust	4200	lb
Dry weight (bare engine)	835	lb
Specific fuel consumption at sea level		
Max rpm	1.08	lb/lb/hr
Max continuous rpm	1.05	lb/lb/hr
Length—intake flange to exhaust flange	75.47	in.
Length—overall	96.1	in.
Diameter	32.4	in.




ENGINE BREATHER OUTLET
FIREPROOF BULKHEAD (INTEGRAL WITH ENGINE)
SHROUD COOLING INLETS (ON HORIZONTAL ℄ OF ENGINE; PORT & STBD INLETS SIMILAR)
HEAT INSULATION BLANKETS
JET PIPE SHROUD
CARTRIDGE STARTER (EXHAUSTS VIA INTAKE GUIDE VANE 4 TO ATMOSPHERE)
ZONE 1
ZONE 2
AIR INTAKE
AIR INTAKE CASING
GENERATOR COOLING AIR TO JET PIPE SHROUD
BEARING SEAL VENTS (PORT & STBD)
GENERATOR COOLING AIR INLET SCOOP
AIR BLEED INTO ZONE 1
AIR OUTLET FROM ZONE 1
VENTILATION AIR INLET (DEFLECTED TO TOP OF ZONE 2)

design progress

by Randolph Hawthorne
Editor

Orpheus turbojet features reliability, light weight

DESIGN objectives for the Orpheus were extremely light weight and exceptional reliability. The MK 803 has an official type test rating of 5000 lb thrust for 835 lb dry weight. Bristol Siddeley Engines Ltd., Filton, Bristol, England, also designed the engine for easy maintenance in the field, good handling characteristics, and a moderate sfc (1.05 lb/lb/-hr maximum continuous rpm). Among the interesting design features are the two-bearing layout; turbine stators integral with flame tubes; accessories grouped below the air intake casing for accessibility; turbine bolted to shaft and to rear center for easy assembly and dismantling; detachable compressor half-casings; and the use of alloy castings rather than built-up components. Write in No. 67 on Reader Service Card for more information.

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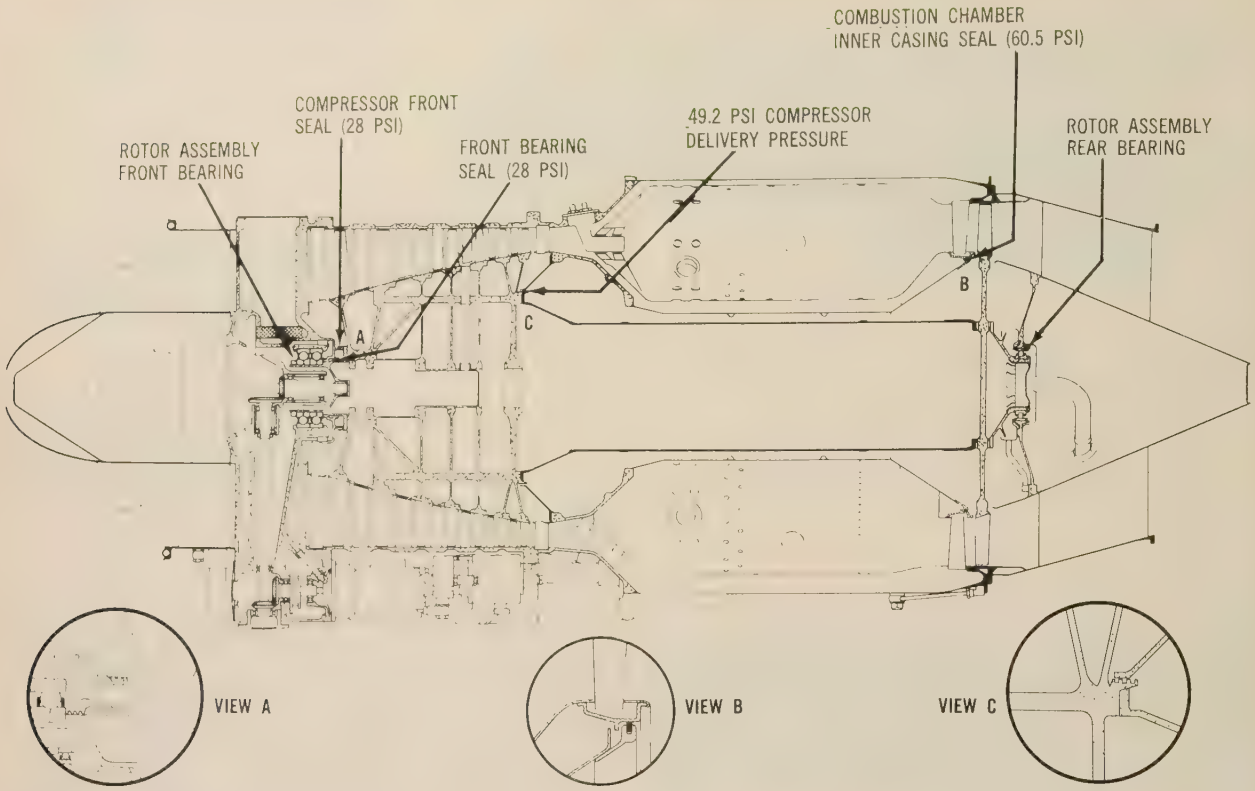
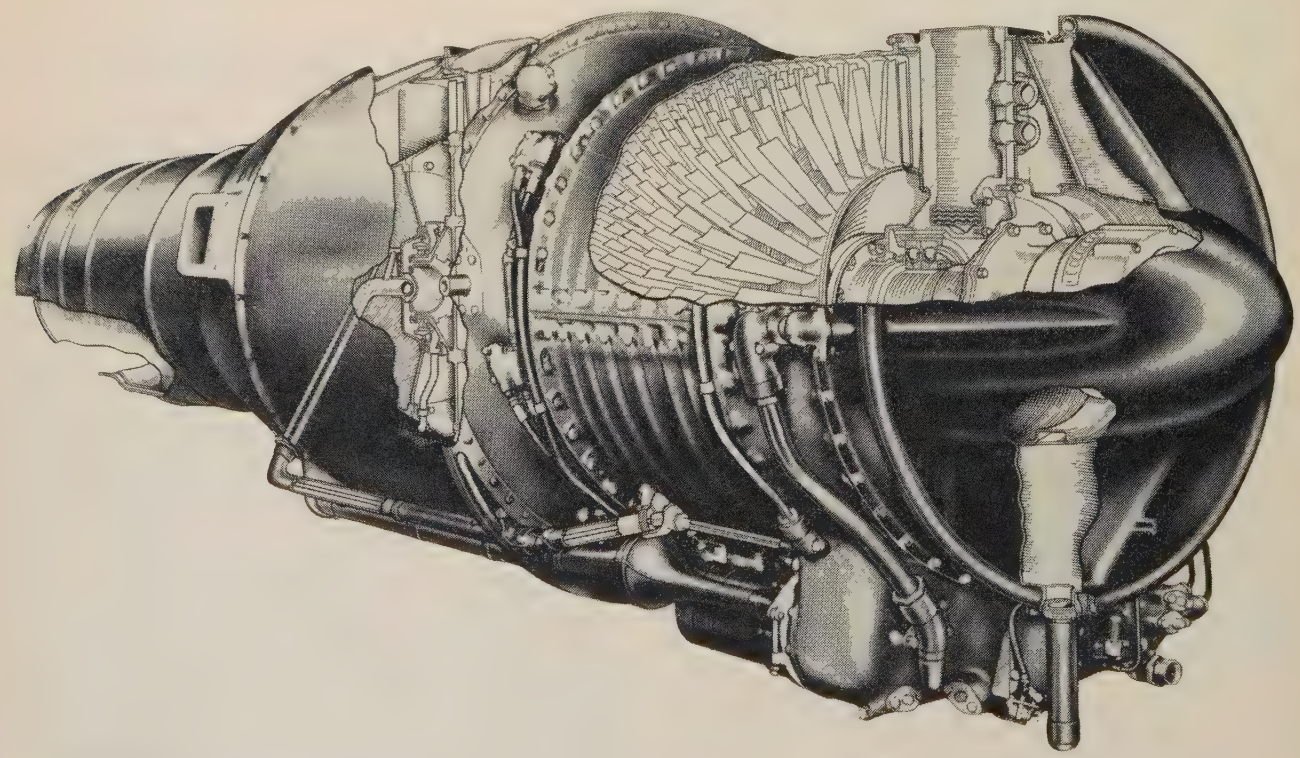
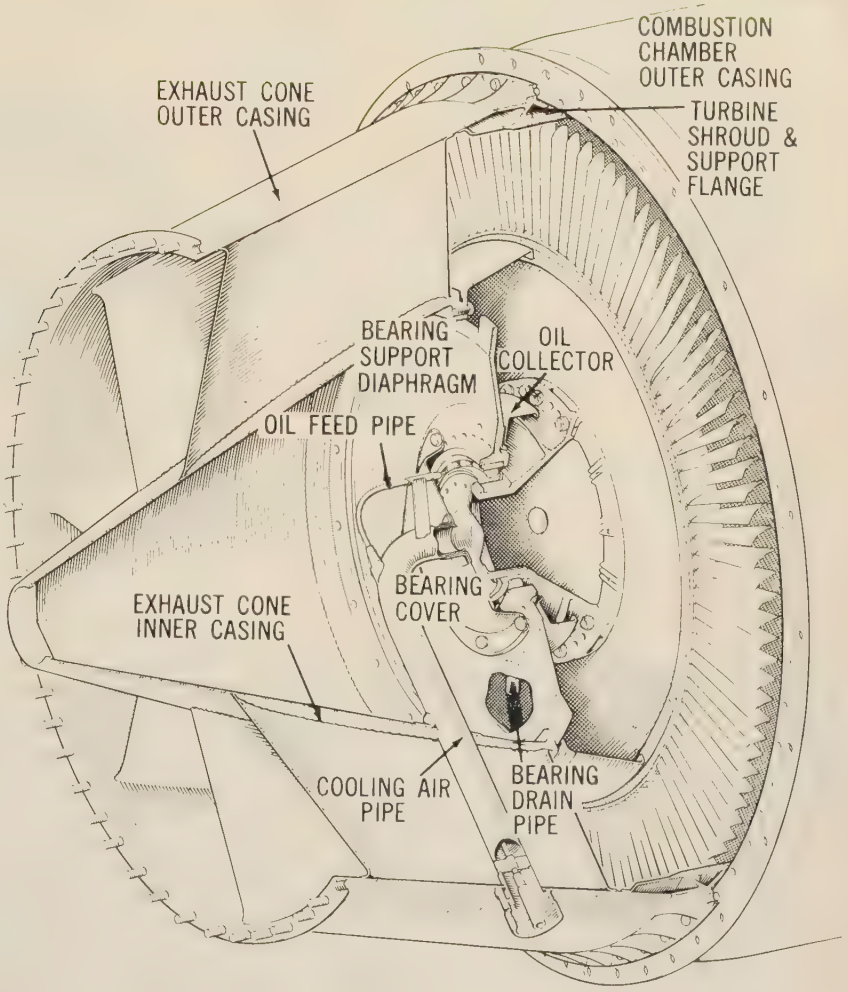


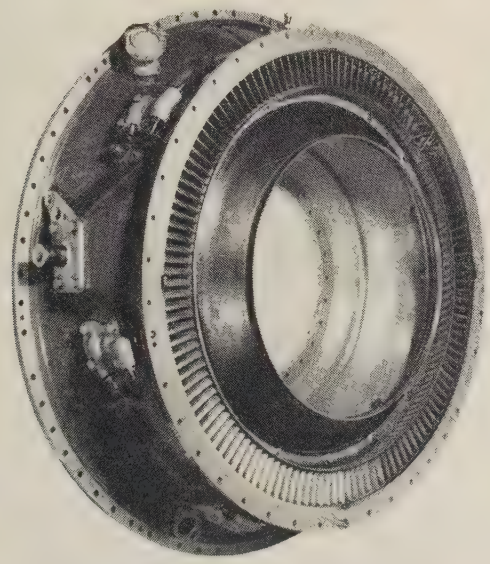
ORPHEUS bearings and air seals.



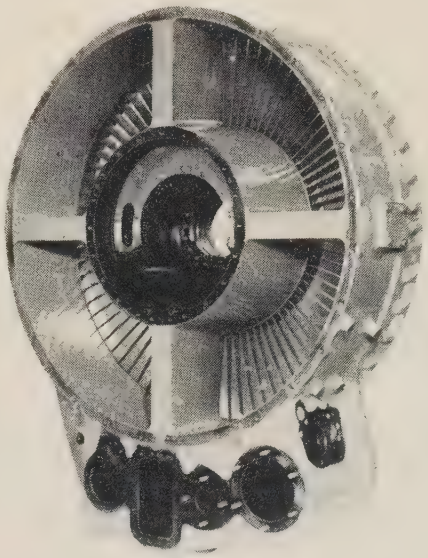
TWO-BEARING layout of Orpheus with two-row ball bearing ahead of compressor and roller bearing aft of turbine.

EXHAUST cone is secured to the combustion chamber's outer casing and carries the rear (roller) bearing of the rotating assembly. The turbine shroud is carried in a support flange secured between the exhaust cone and the combustion chamber's outer casing. The exhaust cone also houses the oil and cooling air feeds to the bearing.

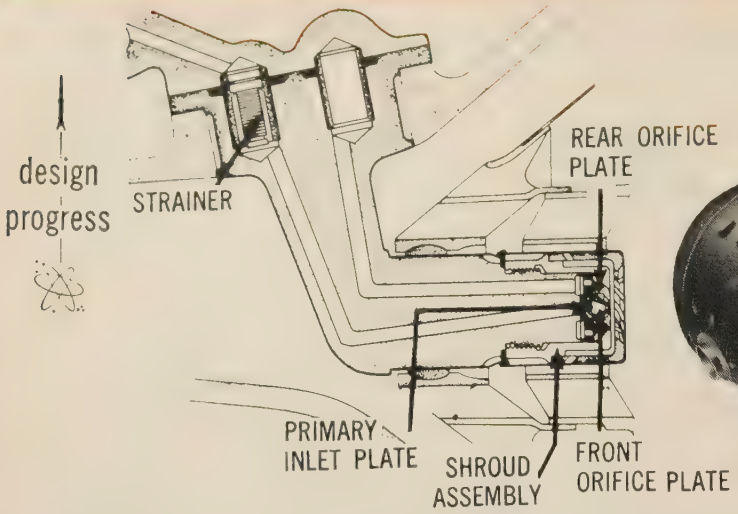


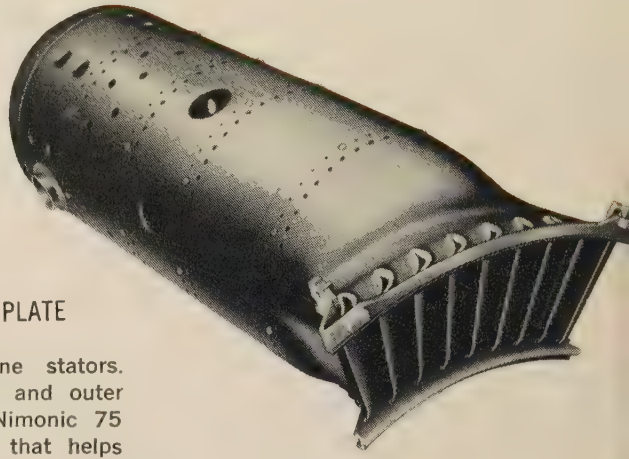


DELIVERY CASING forms the engine's "backbone". It is mounted by a trunnion on each side.

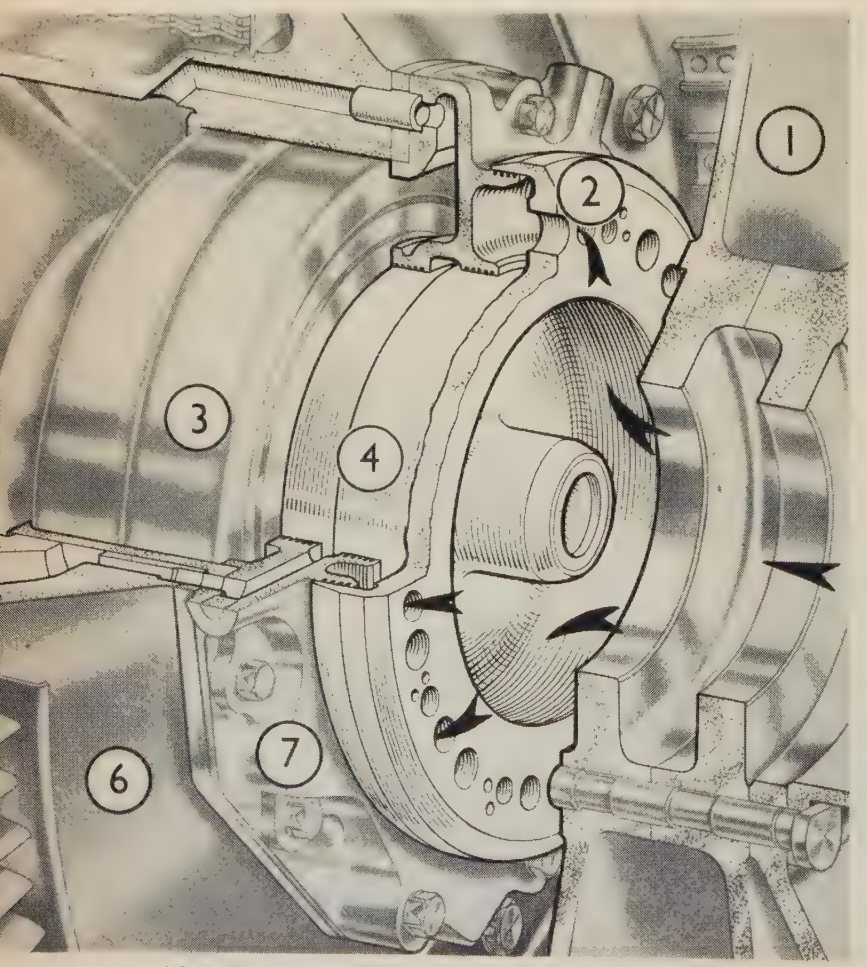


AIR INTAKE casing houses the engine front bearing (inside aperture).



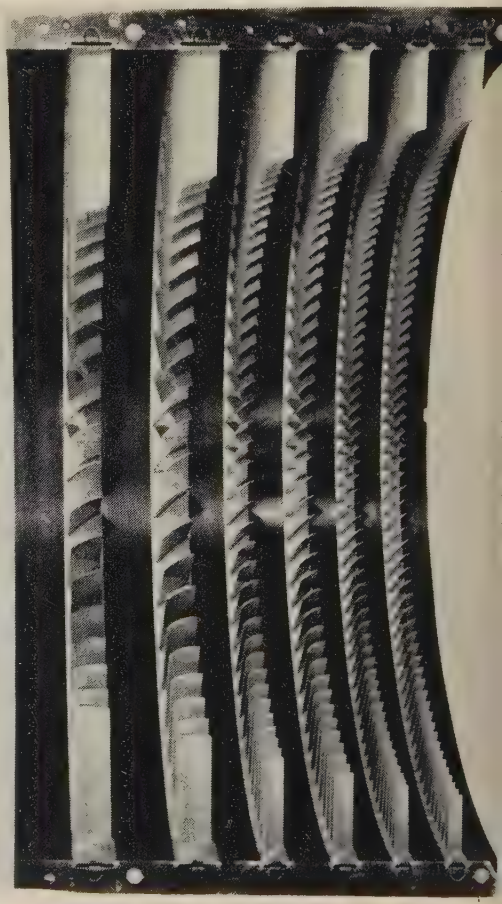


FLAME TUBE rear view (left) shows the integral turbine stators. These are welded hollow sheet metal with machined inner and outer segments welded into place. The seven are made from Nimonic 75 sheet. The duplex burner (above) has an outer air shroud that helps prevent carbon formation. Primary and secondary fuel flows are supplied from the flow distributor.



COMPRESSOR and front bearing seals—(1) compressor rotor, (2) compressor front seal, (3) front bearing, (4) rotor front stubshaft, (5) entry guide vanes, (6) air intake casing, (7) bearing cover.

COMPRESSOR HALF-CASING — Six compress stator blade rows are housed in the cast light all half casings; the seventh row is in the delive casing.



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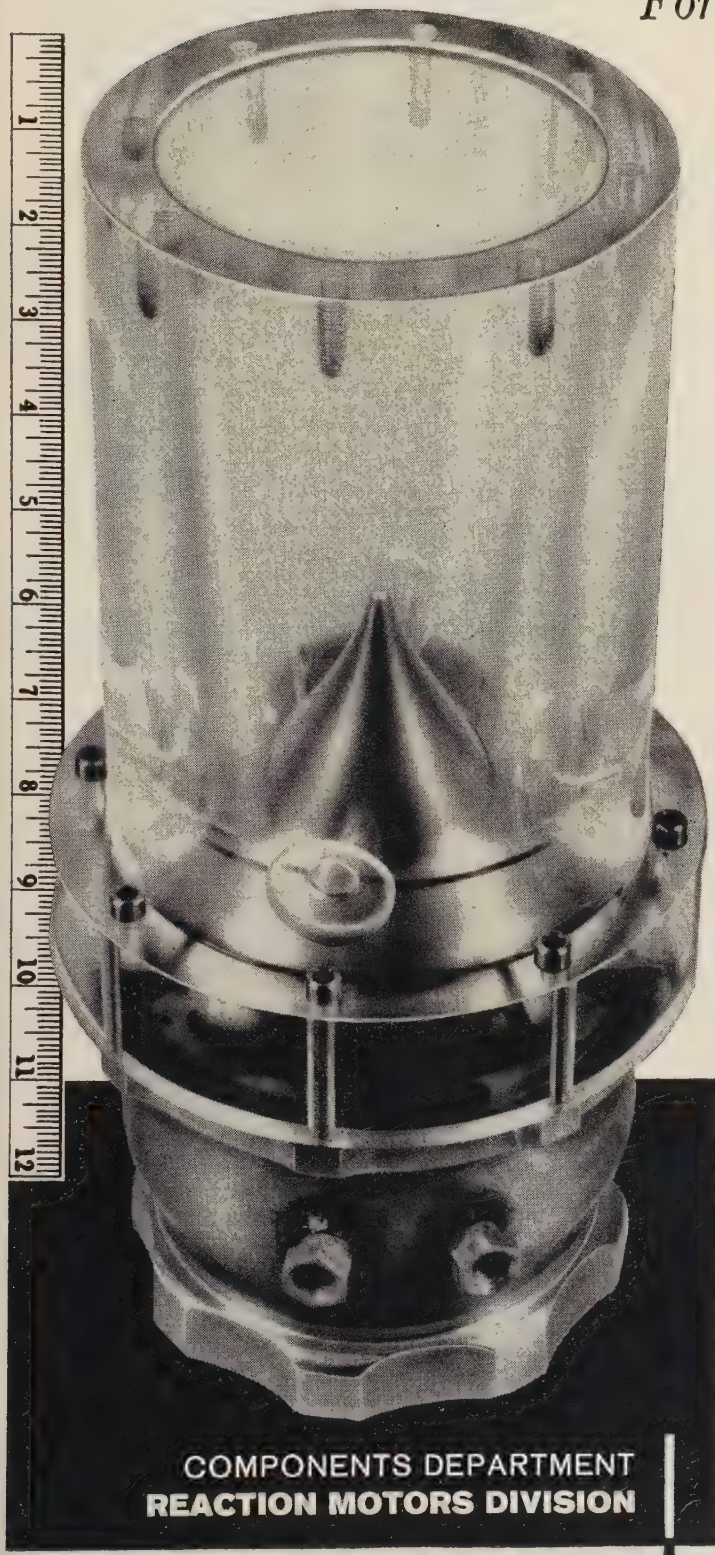

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- **Low pressure drop**
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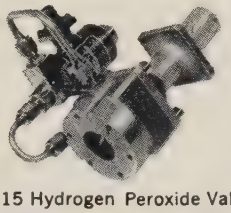
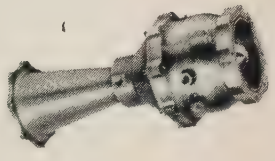
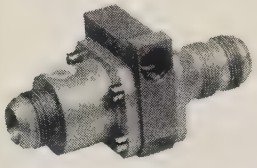


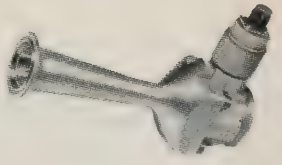
X-15 Hydrogen Peroxide Valve



4" Decaborane Shut-off Valve



Cryogenic Relief Valve



Cavitating Venturi Shut-off Valve

COMPONENTS DEPARTMENT
REACTION MOTORS DIVISION

Thiokol CHEMICAL CORPORATION

Ford Road, Denville, New Jersey

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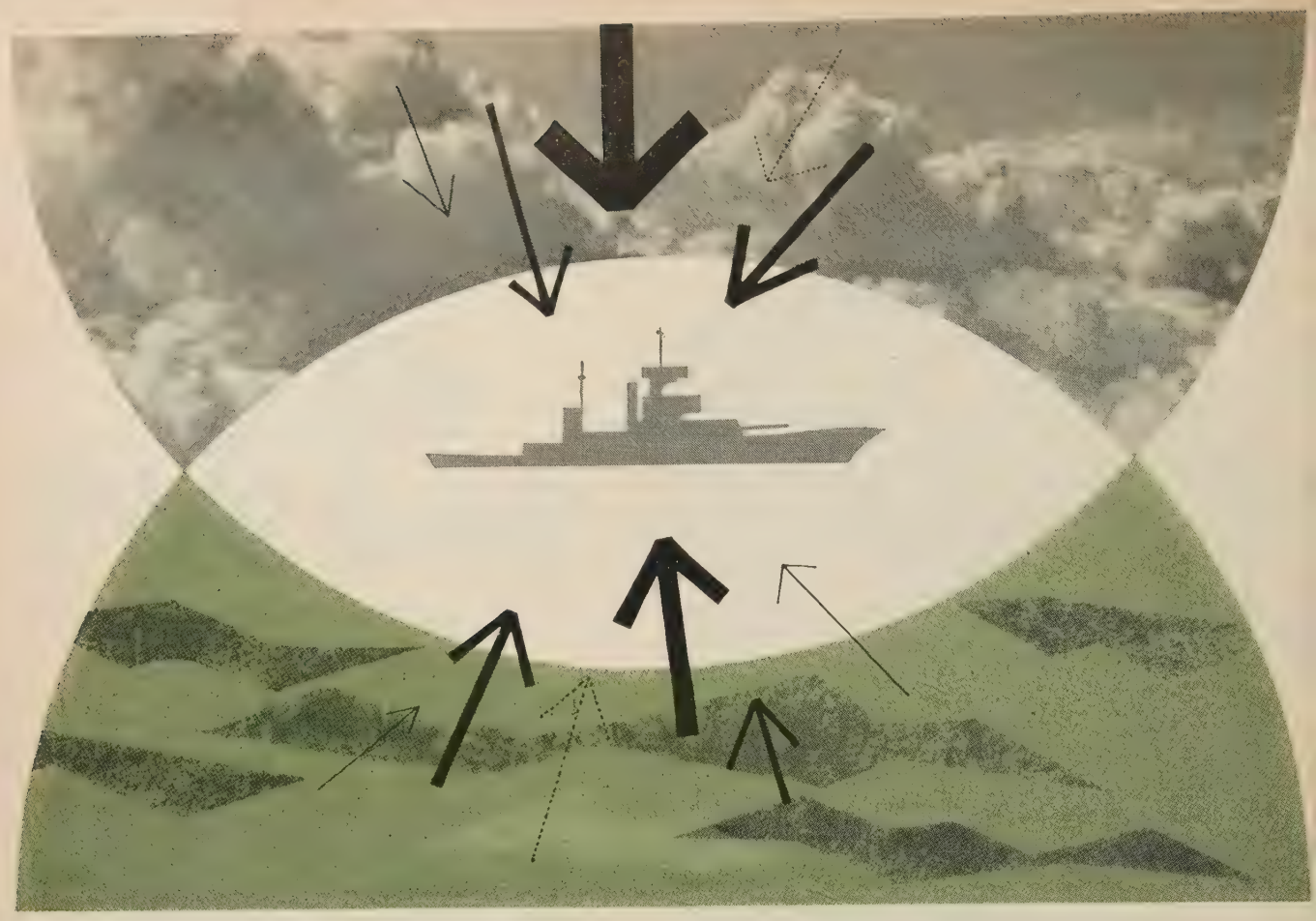

U.S. NAVY LAUNCHES NEW STRIKING POWER

New and deadly weapon for the Navy's arsenal is Corvus, a boost glide missile under development by Temco's Missiles & Aircraft Division. Corvus will be launched from carrier-based aircraft and will give the Navy superior striking power in attacking heavily defended areas, shore installations and surface ships.

Temco is weapon system manager for Corvus and as leader of an industrial team of major subcontractors is responsible for procuring all components, support equipment and services. A test version of Corvus has been successfully air-launched at the Pacific Missile range . . putting this supersonic missile a big step closer to fleet operation.

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Atlas reliability program

yields improved components

Can a reliability program do more than make sure that a vehicle will work? It can, decided Convair-Astronautics—and set up a program designed to get the utmost in performance out of every vehicle component.

by C. C. Campbell,
Senior Reliability Engineer, Convair-Astronautics*

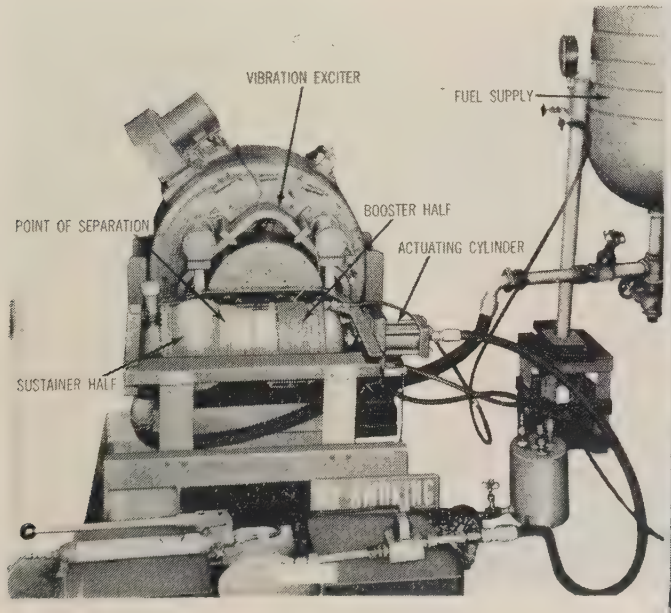
EARLY detection of weaknesses in component design, materials, and fabrication has been the main goal of the Atlas reliability program. It is our idea that a reliability program should lead to better components rather than merely to a numerical assessment of component reliability.

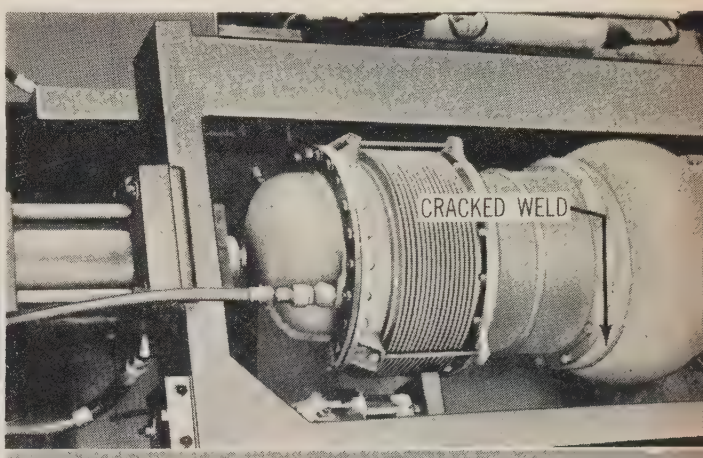
We also do not go along with the approach of the many weapon system contractors who delegate the responsibility for reliability to the parts manufacturer. It seems to us to be much better all around if a special reliability group is set up within the prime contractor's organization. This group can:

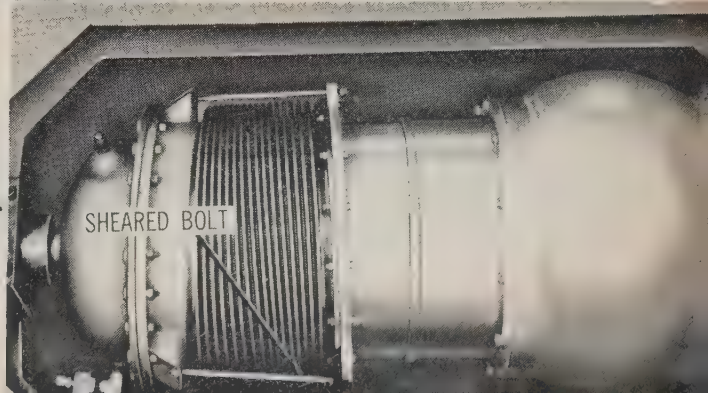
* Convair Div., General Dynamics Corp., San Diego 12, Calif.

more on next page

TEST SETUP for the disconnect valve on the Atlas booster and sustainer fuel supply line and the failures it produced.







• collaborate efficiently with design groups to come up with quick and effective fixes for component deficiencies uncovered in reliability testing;

• keep close liaison with the theoretical groups in the setting up of realistic environmental conditions;

• standardize test requirements for all parts, so that valid comparative analyses of reliability results can be made;

• eliminate all bias from the evaluation of test results;

• run combined environmental tests to reduce testing costs and time.

In the Atlas reliability program, all parts are tested at environmental levels equal to and exceeding those expected in flight.

Parts must pass three series of tests

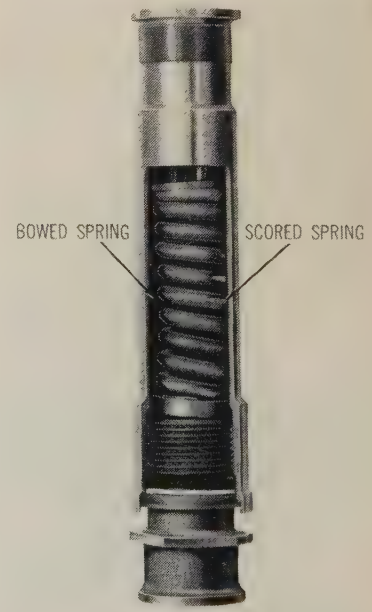
Specifically, Atlas parts must pass three series of tests: First each part is tested at the design levels; then it is tested at two levels of intensity beyond the design requirements. In each test, the part is run for as long as it will be expected to operate in flight.

There are two very important reasons why we test beyond design levels:

• to determine the margin of safety for each part;

more on page 68

TYPICAL spring failure uncovered in the Atlas reliability program.



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Deep in the heart of nearly every ballistic missile in the nation's space-age arsenal is the Statham transducer. Of more than 40,000 parts in a missile, none is more vital than its transducing elements. Without them, it would be difficult if not impossible to determine component reliability or to record the functional performance of the missile in space.

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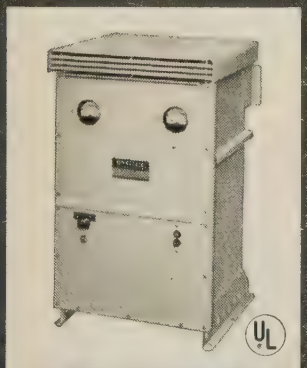

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• to collect data that can be used to assess component reliability —and so avoid further testing—in case the actual flight environments are more severe than those we anticipated.

Wherever possible, environments are combined to produce more realistic test condtions. Most parts now are tested under combined vibration, altitude, low temperature (to –300 deg F) or programed radiant heat (to 50,000 btu/sq ft/hr). Later on we expect to include sustained accelerations in the combined test environment.

Sample size varied from five to twenty

The first step in the reliability test program is to decide which parts to test and in what quantities. Generally, you select those parts whose failure would endanger the success of a mission. The number of samples you test is related to the total number of times that a given part appears in your vehicle and to its importance to the rest of the vehicle. In the early stages of the Atlas reliability program, the sample size varied from five to 20 specimens per part.

Obviously, the more samples you test, the better are your chances of catching performance variations between samples. For example, in a disconnect valve test on the Atlas, the poppet in the missile part of the assembly stuck open on one of 10 units we tested. In flight, this type of failure would have meant the loss of missile pressurization. Our chances of spotting this danger would have been slim if only one sample had been tested.

Once the parts to be tested and their quantities are decided on, a reliability test outline (RTO) is prepared for each part. This outline is used by the test lab as a guide in writing up the detailed test procedures.

The RTO requirements apply only to reliability; they do not include test requirements for conformance with all the details of the procurement spec. However, this spec is used to determine the tolerance requirements.

Following the review and approval of the test procedures, the parts are released for testing. The reliability group monitors the tests, and is immediately notified by the testing lab when a failure occurs—corrective action can be taken without waiting until all the tests have been completed.

The final test results are reviewed by the reliability and design groups with an eye toward an initial evaluation of component reliability. A final statistical analysis is then made by the reliability group. It includes studies of the performance variability for each part as a function of environmental stresses and of the performance variability between different specimens of the same design as well as an evaluation of comparative reliability.

more on page 71

TYPICAL structural failure of Atlas component in reliability tests.

MOON GARDEN

You can't grow anything on moon soil . . . but Republic is . . . raising turnips, carrots, beets and snap beans in its lunar greenhouse experimental garden. ➤➤➤ Republic is working on lunar garden studies as part of a research program to determine the feasibility of establishing a base on the moon. ➤➤➤ Hyman Stein, manager of space projects and studies for Republic's Applied Research and Development Division . . . and his "green thumb staff" (Bill Taufman seen here), maintain a constant, studious vigil over these tests. ➤➤➤ A basic aim is to determine at how low a pressure vegetables can be grown to maturity. The lower the pressure, the less weight of the greenhouse structure. And weight is critical in delivering a payload to the moon. ➤➤➤ These experiments will determine whether significant increases in crop production can be obtained by lengthening the working day as past tests indicate. Our Moon Garden studies are but one of many bold concepts under development as part of Republic's multi-million dollar exploration into the realm of advanced aircraft, missiles, space travel and space.

REPUBLIC AVIATION

FARMINGDALE, LONG ISLAND, N. Y.

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Experiments being carried out in Republic's preliminary laboratory will be housed in our new 14 million dollar research and development center, scheduled for operation early in 1960.

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Pratt & Whitney Aircraft's J-75, the world's most powerful production jet engine, is demonstrating its reliability, stamina, and outstanding fuel economy in two of the U. S. Air Force's newest aircraft—the Republic F-105 fighter-bomber and the Convair F-106 interceptor.

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REPUBLIC F-105 CONVAIR F-106 DOUGLAS DC-8 BOEING 707

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Flight Propulsion by **PRATT & WHITNEY AIRCRAFT**

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Some specimens may all perform within the spec tolerances and yet vary enough in performance to be critical. Such a situation, of course, would not be uncovered by an analysis that merely takes into account the number of recorded failures.

Following the final analysis, component performance is classified as either satisfactory, an out-of-tolerance failure, or a catastrophic (sudden-death-type) failure. Within these categories, each part is further classified according to the number of failures. The final listings show the relative reliability of each tested part. The emphasis then is put on improving the least reliable parts.

Program paid off from the start

This basic reliability program paid off on the Atlas from the very start. Several serious failure trends were revealed early in the test program. If it had taken us longer to spot them, they would at best have been time-consuming to correct and at the worst could have caused a flight failure.

For example, a failure trend became recognizable when several coil springs failed during compression tests under simulated environmental conditions. We found that the coil spring bowed when compressed and rubbed against its housing during operation. It scraped the housing and caused a serious contamination problem. There were also several spring fractures, which resulted in erratic performance.

Failure of any one of the springs during operation could have caused a flight failure—a high price to pay for a relatively inexpensive part. Once the problem was recognized, it was easily remedied of course.

Another failure trend involved a large number of parts that lost their structural integrity in vibration tests. In several cases, these failures showed up around welded areas. The cause was traced to faulty welding techniques.

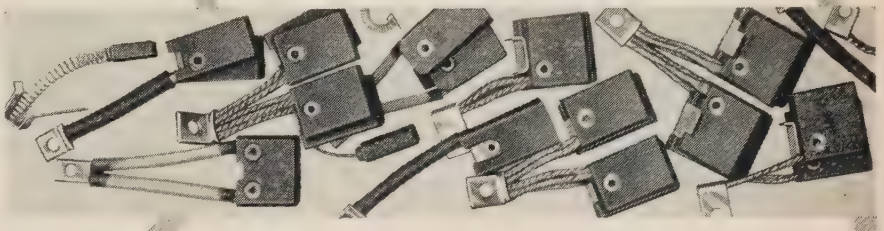
The Atlas reliability program, incidentally, did more than just provide data for detecting failure trends. It also made suppliers aware of the high performance qualities expected of their products and prompted them to improve their fabricating and testing techniques.—End

They "go easy" on commutators and slip rings!

By no means the least of the many advantages of Stackpole Quick-Filming Brushes is their ability to eliminate a great deal of maintenance and equipment reconditioning. The uniform distribution of their high-altitude protective ingredients avoids grooving commutators and slip rings—and, in many cases, adds greatly to operating stability at elevated temperatures.

Five Stackpole Quick-Filming Brush Families—each with countless modification possibilities—cover practically any high-altitude brush application, present or pending. No sea level break-in filming run is needed. Commutation, stability and life are excellent through an exceedingly broad range of operating conditions. Brush temperatures are held to a lower, more stable level.

Write for High Altitude Brush Bulletin.



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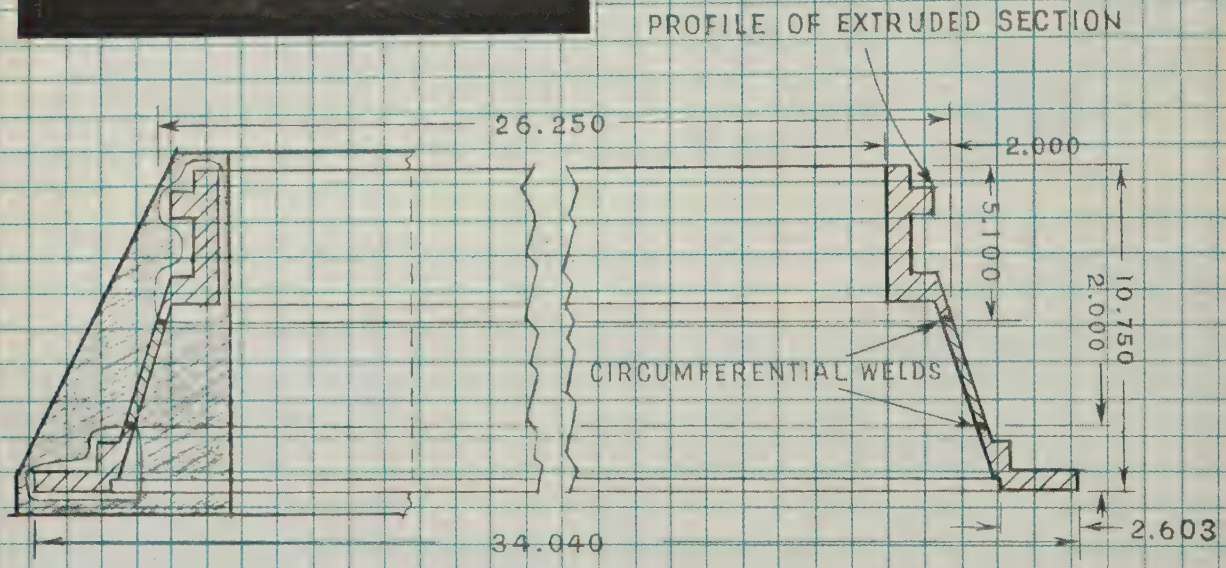

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AMERICAN WELDING

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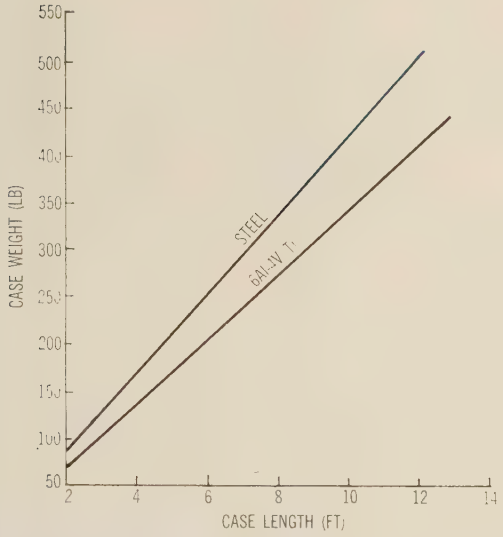

Table I:

Reproducible Strengths of Three Titanium Alloys

	Ultimate Tensile Strength (ksi)	Yield Strength (ksi)	Elongation (per cent in 2 in.)	Yield-Strength Density Ratio (in.)	Ratio of Notched to Unnotched Strength (K_t = 4)
MST 6Al-4V	150	140	10	870,000	1.25
MST 25Al-16V	165	150	5	890,000	1.12
13V-11Cr-3Al	170	160	5	910,000	1.07

COMPARISON of steel with 200 ksi yield strength and Mallory-Sharon MST titanium alloy with 140 ksi yield strength for use in a hypothetical 40-in.-diameter rocket case at a given burst pressure. Only 34.6 lb of titanium is needed per foot of case length as against 42.6 lb of steel.

Titanium
provides notch-ductile rocket cases

Combining a favorable strength-weight ratio with good notch ductility, titanium deserves close study as a material for rocket cases. Here is a report on three titanium alloys suitable for this application.

by A. N. Eshman, Manager, Military Market Development, Mallory-Sharon Metals Corp.[1]

STRENGTH-WEIGHT ratios of 1,000,000 and more have been set up as the target for missile structures. In titanium, such a ratio requires a yield strength of 160,000 psi; in steel, 280,000 psi is needed.

These strengths must be considered in terms of weldments and heat-treated, large-diameter, thin-wall cases exposed to high internal and/or external pressure. In these cases, ultra-high-strength steels have marginal ductility after heat-treat to a strength-weight ratio at which they could compete with titanium.

In an ordinary tensile test, 5Cr tool steels, 4340 and its modifications, and 422 steel can develop yield strengths of 230-280,000 psi in uniaxial tension. However, they fail catastrophically in biaxial tension, such as is produced in hydrostatic testing or when a rocket case is fired. The trouble is that these steels have too much notch sensitivity, or not enough notch ductility.

Any useful structural metal must have enough ductility to flow in an area of localized high stress exceeding the yield strength and so redistribute the stress. Otherwise, a brittle failure occurs. The ratio of notched to unnotched yield strength for 4340 heat-treated to 230,000 psi yield is less than 0.75 in tests involving the severe notch sharp-

more on next page

(1) Mallory-Sharon Metals Corp., Niles, Ohio.

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Table II: Effect of Cold-Work on 13V-11Cr-3Al Titanium

Condition	Ultimate Tensile Strength, (ksi)	Yield Strength (ksi)	Elongation (per cent in 2 in.)
Solution - treated (½ hr @ 1450 deg F AC)	145	140	10
Solution - treated & aged 72 hr @ 900 deg F)	209	188	4.5
Solution - treated, 12 per cent cold-rolled & aged (10 hr @ 900 deg F)	209	192	5.5
Solution - treated, 20 per cent cold-rolled & aged (10 hr @ 900 deg F)	215	200	4.5
Solution - treated, 35 per cent cold-rolled & aged (10 hr @ 900 deg F)	225	204	3.5

ness ratio of a/r=100 (K_t=9.5). By contrast 6Al-4V titanium heat-treated to 155,000 psi yield and tested under the same conditions, has a ratio of 1.2.[2]

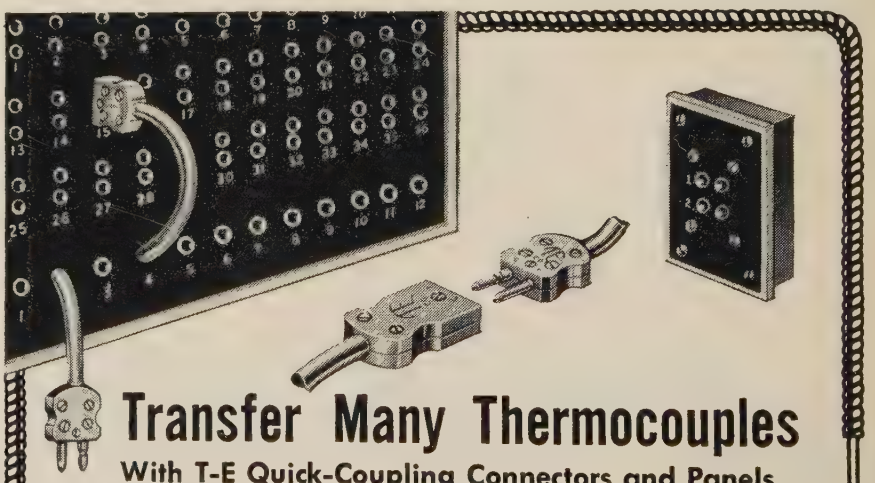
At these strength levels, the useful notched strength-weight ratio would be only 610,000 psi for 4340 against 960,000 psi for 6Al-4V titanium. Higher useful notched strength in steel can be obtained by reducing the unnotched strength.

Many tests have been developed by engineers trying to predict the optimum properties for a rocket case, but few have proved fully satisfactory. In the end, it's usually necessary to build and field-test a case and so reproduce the exact conditions of stress. Most tests have shown that, for yields above 200,-210,000 psi in steel, notch ductility is too low for case reliability. The strength-weight ratio for these yields of 740,000 psi—some 25 per cent less than what you can get in titanium at a ductile level.

Three titanium alloys—6Al-4V; 2.5Al-16V, and 13V-11Cr-3Al—

(2) Sachs et al., "Notch Sensitivity of Ti Alloys and Heat-Treated Steels;" Syracuse U., Jan. '58.

more on page 76



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Connector Panels T-E has one for your exact needs. These panels provide flexible, centralized control in transferring any number of thermocouples to indicating, multi-point recording and controlling pyrometers. Ideal for patch panel use, they are available in many compact shapes and sizes — with interchangeable plugs and jacks in I-C, C-C, and C-A. A panel for 48 thermocouples and 16 pyrometers measures only 13¼" x 7⅞". Polarity markings and screw-fastened connections make wiring easy.

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Thermo Electric Co., Inc.

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In Canada—THERMO ELECTRIC (Canada) Ltd., Brampton, Ont.

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FOUND:

an intellect that can think anywhere

The systems of tomorrow will require digital computers that can think *anywhere*—intellects that will remain superior in any environment.

ARMA—already producing computers for its inertial guidance system in the ATLAS ICBM—has accepted the challenge and developed a lightweight, second-generation digital computer applicable to *all* types of navigation. It can be used in space, atmospheric, surface, subsurface and ground navigation, making possible programming flexibility.

This all-solid state computer, with *no moving parts* and using silicon semiconductors exclusively, has a memory that is non-volatile and has non-destructive readout. And this computer has 40 per cent fewer parts than ARMA's first-generation production model, which has a test performance unequalled by any other digital computer.

An even more sophisticated third-generation computer, surpassing the reliability of the first two with still less weight, will be produced in the future by ARMA. The reliability of all three generations will be assured by thorough testing in ARMA's environmental facilities—the most complete in the industry.

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Attention, Engineers: Write to E. C. Lester, Emp. Supv., about career openings in R & D programs.

AMERICAN BOSCH ARMA CORPORATION

RING-ROLLED cylinder and formed dome of MST 6A1-4V titanium for an experimental 20-in.-diameter rocket case.

are recommended for rocket cases. *Table I* shows their present reproducible strengths at adequate weld ductility levels.

Five main methods of case fabrication have been used:

(1) *Roll-and-weld construction*—The case body is rolled from sheet or plate, welded longitudinally, and then girth-welded to spun, drawn, or forged heads.

(2) *Forged and rolled rings*—Billet stock is forged to a doughnut configuration, rolled into rings with relatively thin walls, and girth-welded to form the body, which is then girth-welded to aft and forward closures.

(3) *Forged and machined rings*—Rings are forged as in the previous method, machined to size, and girth-welded together. Since this process produces shorter ring sections, more sections are needed.

(4) *Roll-formed case*—Billet stock is forged to a starting hot cup and ring configuration. The forgings are rolled into two integral case sections, one of which forms forward closure and part of body, while the other is the aft body. Only one girth weld is necessary.

(5) *Ribbon wrap*—Several layers of thin, high strength strip are wrapped around a mandrel and bonded together.

Which of these methods is best in a given case depends on the available equipment, the fabrication know-how, and the tightness of the required tolerances—which might be no more than ± 0.002 in. on a 40-in. case. Process 1 is used for most production cases, despite the severe penalty of the longitudinal weld. Hoop stress in this weld is twice as much as in the girth weld.

Both 6Al-4V and 13V-11Cr-3Al

more on page 78

Designed especially for High Strength—High Temperature and liquid oxygen and other corrosive applications, Cherry Aircraft Lockbolts* are now available in austenitic A-286 Stainless Steel.

Available for the aircraft industry in a wide range of diameters, grip lengths and head styles in A-286 . . . Cherry Lockbolts are also produced in Alloy Steel and Aluminum.

Cherry Lockbolts are structural fasteners providing simplicity and speed of installation with uniform high tensile preloads.

Shop men like them.

For information on Cherry Aircraft Lockbolts, write Townsend Company, Cherry Rivet Division, P.O. Box 2157-P, Santa Ana, California.

*Licensed under Huck patents RE22,792; 2,114,493; 2,527,307; 2,531,048; 2,531,049 and 2,754,703

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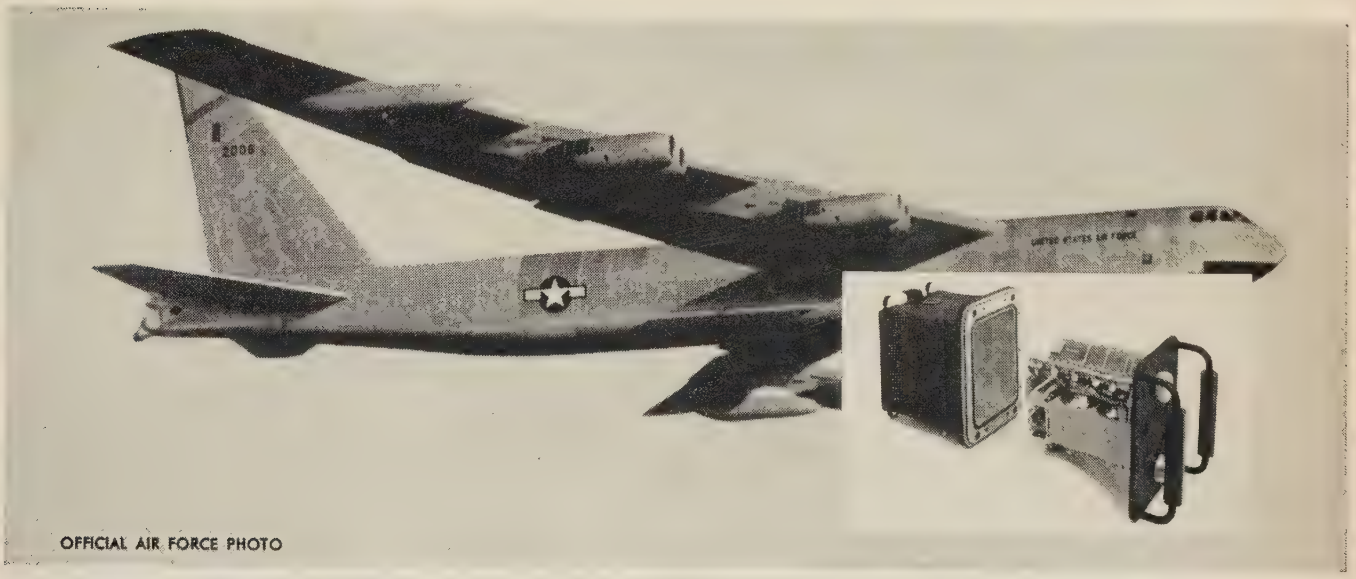
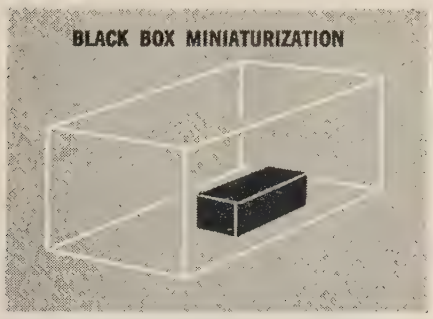
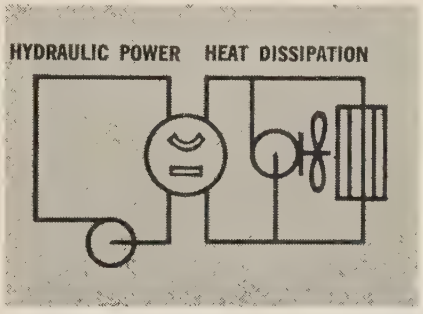
IBM cools current deflection amplifier with Coolanol 45



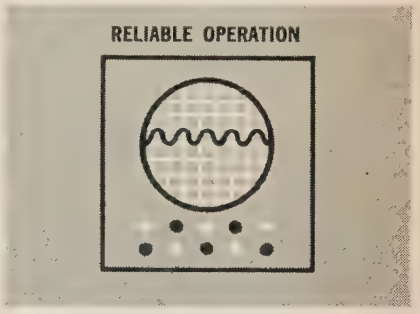
Coolanol 45 dissipates heat from the 360-watt Current Deflection Amplifier produced by IBM Military Products Division for the AN/ASB-4 bombing/navigational system—operational in the B-52 bomber.



For compact design . . . Coolanol 45 dissipates the increased heat created when you must pack more power into less space. Liquid-cooling allows miniaturization of components that must be lightweight, yet powerful enough for today's advanced system designs. It lends itself well to package systems of individual units which can be removed, serviced and replaced easily.



For design simplicity . . . call on the ability of Coolanol 45 to function as a coolant-dielectric *or* as a hydraulic fluid. Coolanol 45 pumps and cools efficiently from -65° to 400° F.—performs well over an environmental temperature range even wider. You can eliminate the variables of multiple fluids or multiphase fluid systems by standardizing on versatile Coolanol 45.



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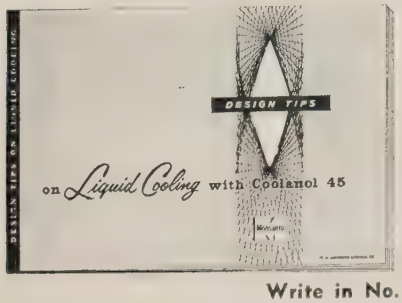

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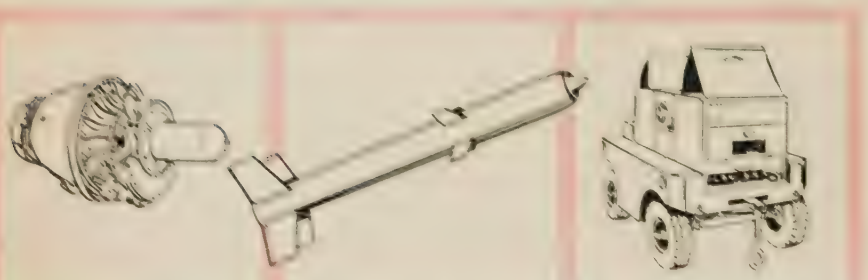

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can be made by this process. In both cases, a beefed-up weld is recommended. Solution-treated plate or sheet may be chemically or mechanically milled to leave a weld pad, formed into a cylinder, thermally aged in fixtures, and welded.

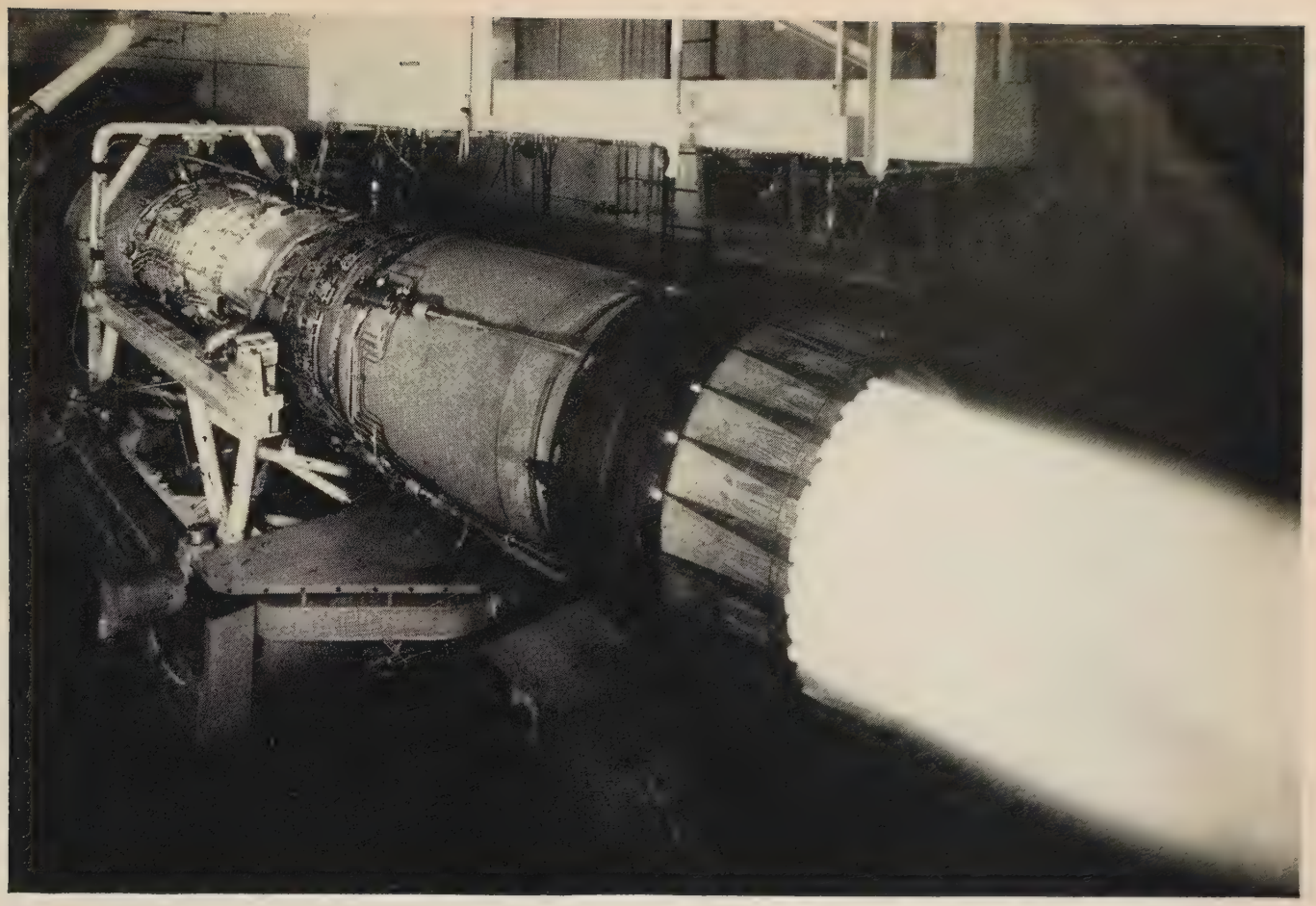
For 6Al-4V, six hours' aging at 1000 deg F will give a minimum yield of 140,000 psi; for 13V-11Cr-3Al, 60 hours at 900 deg F gives a minimum of 170,000. Welding reduces the strengths in the pads to about 120,-130,000 yield in both alloys.

This process is not recommended for 2.5Al-16V, since in this case welding without subsequent aging leaves the weld metal in a low strength, solution-treated condition. An alternate method, applicable to all three alloys, would be to weld the solution-treated components and then overage the whole assembly.

Higher weld strength with lower ductility and higher parent metal ductility with lower strength are obtained in this alternate approach. Duplex aging of 13V-11Cr-3Al at 900 deg F (72 hours) and then at 1050-1075 deg F (30 minutes) gives about 160,000 psi yield and 4-6 per cent elongation in a two-inch gage length (with the weld parallel to specimen length). With 2.5Al-16V aged at 950-975 deg F (three hours) and then at 1025 deg F (1-2 hours), you get 150,000 psi and 3-5 per cent weld ductility; with 6Al-4V aged at 1000 deg F, 140,000 psi and 5-7 per cent weld ductility.

Processes 2, 3, and 4 are applicable to all three alloys. Each requires solution treating either of case components or of half the whole case body as individual units. The high solution temperature for 6Al-4V (1650-1700 deg F) causes difficulties in the jigging and water quenching needed to maintain the tolerances of process 4. The other two alloys can be air-quenched from the solution-treat temperature (1375-1400 deg F) and aged to the strength levels we have indicated.

Its cold-worked and aged strength makes 13V-11Cr-3Al suitable for Process 5. Cold reduction accelerates the transformation and so gives you a chance to use much shorter aging cycle (*Table II*). The cold-worked and aged material is comparable to the solution-treated and aged material in both strength and ductility. Write in No. 69 on Reader-Service Card for more information.—Ed.



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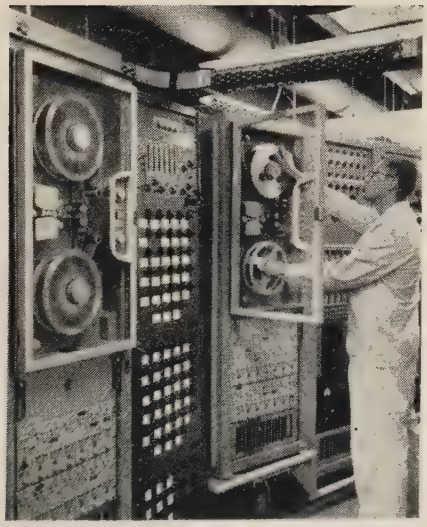

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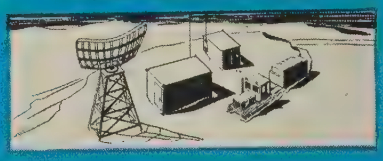

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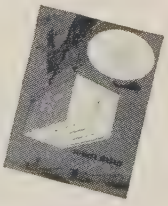

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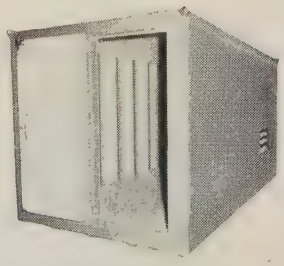

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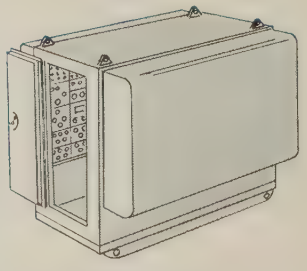

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Anti-icing

for a turboprop transport

The design of ice protection for a modern transport is as complex as it is critical. This report on the anti-icing system of the Lockheed Electra gives a good idea both of the theoretical considerations and the practical hardware involved in ice protection.

by B. L. Messinger and J. B. Werner,
Manager & Group Engineer, Thermodynamics Dept., California Div., Lockheed Aircraft Corp.*

THE ice protection system of the Lockheed Electra uses last-stage compressor bleed air from the transport's Allison 501 turboprops at its uncooled temperature of 550 deg F and unregulated pressure of up to 150 psi. It's true that taking compressor bleed air from a turboprop causes significant power losses, but these are offset by the advantages of a bleed-air ice protection system: low weight, high reliability, and simple maintenance. These advantages weigh even more heavily in the balance if, as in the case of the Electra, the system normally will operate only for short periods per flight.

* This is a condensation of a paper, "Design and Development of the Ice Protection Systems for the Lockheed Electra," given at the Aircraft Ice Protection Conference sponsored by Napier in Luton, Bedfordshire, England, last June. The authors wish to acknowledge the help of F. R. Mastroly, Jr., and A. W. Turner.

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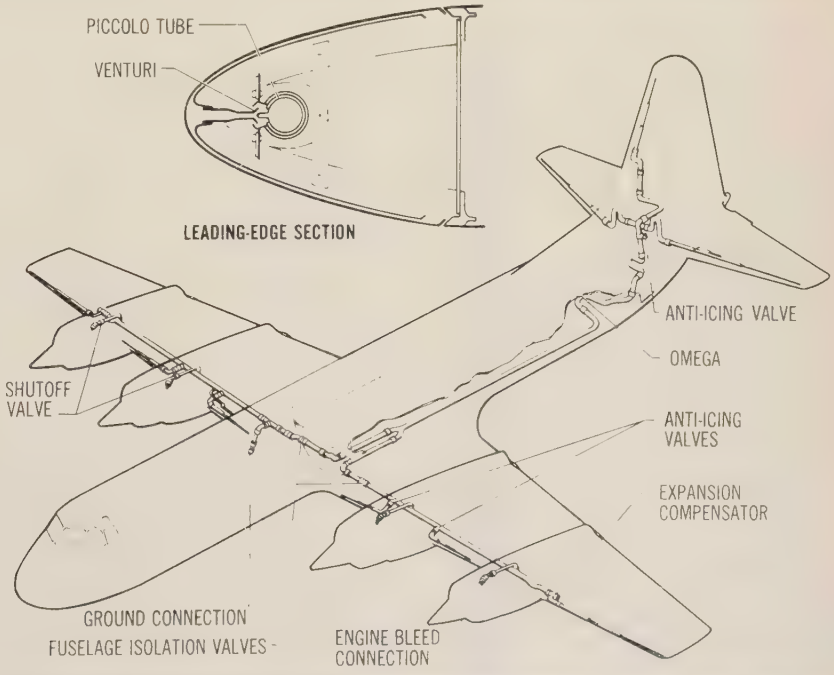
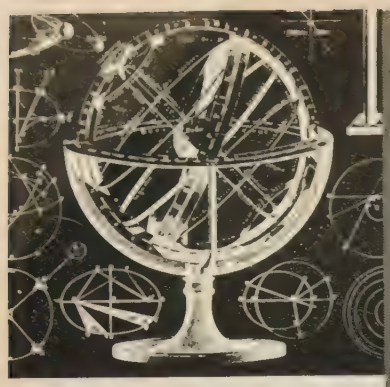


FIGURE 1: Bleed air distribution system for ice protection of the Electra.



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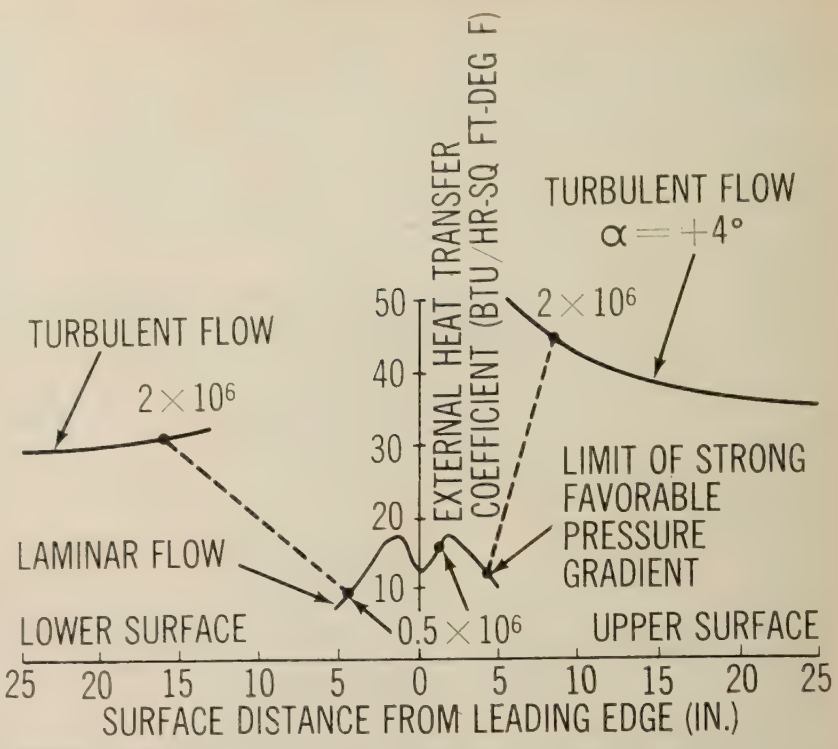

FIGURE 2: Distribution of the external heat transfer coefficient for the Electra's intermediate wing station 257 at 300 knots TAS, 20,000 ft, and —8 deg F ambient air temperature. Local Reynolds numbers and transitions (dashed lines) are shown.

Because of the large anti-icing bleed air flow required by the U.S. Civil Air Regulations (CARs) at high flight speeds, Lockheed found, the airfoil part of the Electra ice protection system worked equally well in anti-icing and de-icing (cyclic-removal) operation. In the latter mode of operation, the power penalties are lower.

The design point for the entire system corresponds an altitude of 20,000 ft, a speed of 300 knots TAS, an ambient air temperature of +15 deg F, a volume-median drop size of 20 microns, and a liquid water content of 0.44 gm/m^3. This point meets both the requirements laid down by the CARs and those of possible future military applications of the Electra.

In choosing a design point, Lockheed also had to consider engine power. Fortunately the 501 operates at constant speed under all flight conditions, so that bleed temperature is independent of power and altitude. As noted, it is about 550 deg F at the design point. The bleed pressure varies only slightly with power and ambient temperature; it depends chiefly on altitude and bleed percentage. About eight per cent bleed is needed at the design conditions, and the system was sized for adequate flow at this bleed rate and at 60 per cent normal rated power.

The wing and empennage ice protection systems are designed primarily to evaporate all impinging water up to the design icing condition. Their bleed-air requirements were determined from an energy balance between the external heat losses — convection cooling of the heated surfaces, evaporation of the impinging water, and sensible heating of the water up to the skin temperature—and the enthalpy drop of the air flowing through double-skin heating passages (see *Table*). The evaporation-rate heating term included a wettedness factor (F) to allow for the fact that water flows along the surface in narrow rivulets rather than as a continuous sheet.

To solve this energy balance quietly and accurately for the required air flow, a simplified graphical technique was used. The result was verified in a point-by-point analysis of the chordwise skin and air temperature distribu-

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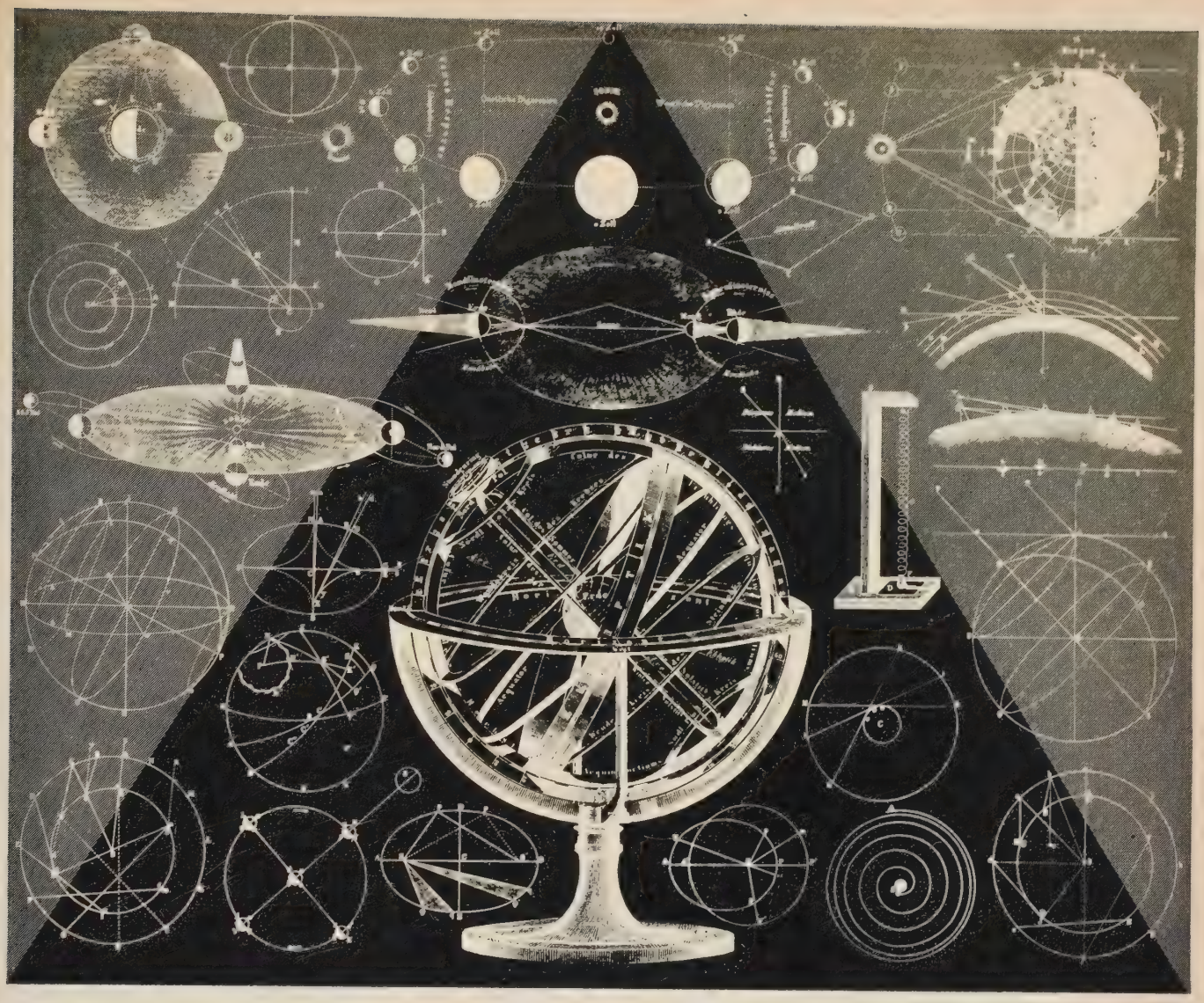

Guided tour of the solar system

The new NASA Thor-boosted research rocket, DELTA, now being constructed by Douglas, will set up big signposts for further space explorations. Combining elements already proved in space projects with an advanced radio-inertial guidance system developed by the Bell Telephone Laboratories of Western Electric Company, DELTA will have the versatility and accuracy for a wide variety of satellite, lunar and solar missions. Douglas insistence on reliability will be riding with these 90 foot, three-stage rockets on every shoot. At Douglas we are seeking qualified engineers to join us on this and other equally stimulating projects. Some of our requirements are listed in our column on the facing page.

Maxwell Hunter, Asst. Chief Engineer—Space Systems, goes over a proposed lunar trajectory with Arthur E. Raymond, Senior Engineering Vice President of DOUGLAS

MISSILE AND SPACE SYSTEMS ■ MILITARY AIRCRAFT ■ DC-8 JETLINERS ■ CARGO TRANSPORTS ■ AIRCOMB ■ [illegible]

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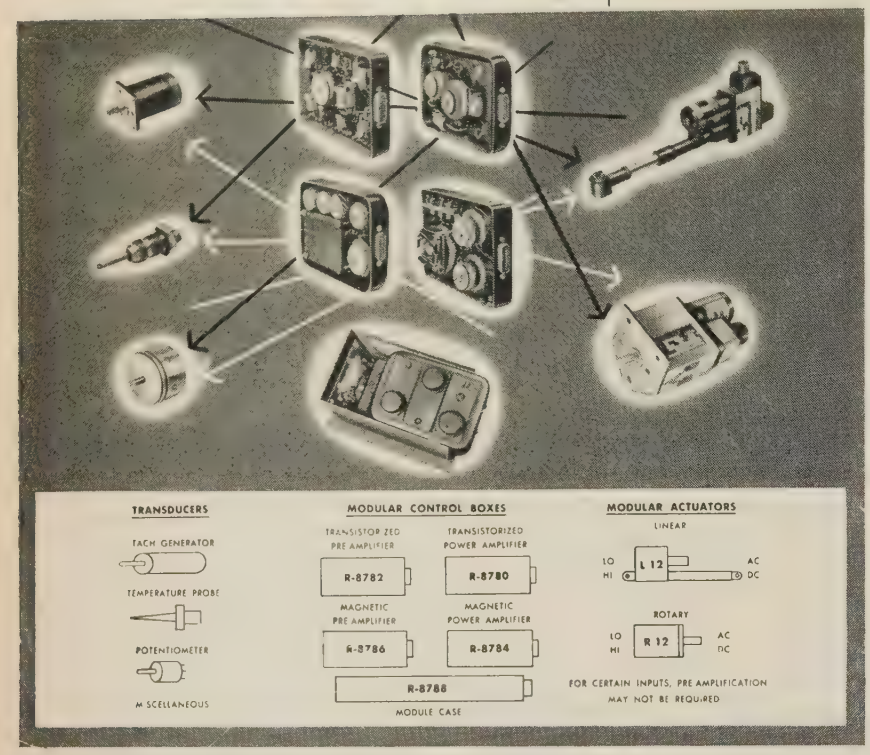

Heart of Airborne's new modular control systems is a contactorless control package consisting of a standardized case (3 x 3½ x 5 in.) into which packaged preamplifier and power amplifier subsystems are plugged. Amplifiers drive actuators having maximum operating loads up to 500 lb. (linear) or 100 in.-lb. (rotary). Modular design permits delivery of relatively complex systems in minimum time.

Over the past 6 years, Airborne has designed and produced a number of special electromechanical control systems for aircraft-missile use. While these have differed in their functions, many of them have nevertheless employed essentially similar components. Thus our policy has been to seek increasing standardization of parts through modular design—to the point where we can now offer complete systems engineered under this concept.

From transducer through actuator, these new Airborne systems are assembled entirely from standardized, interchangeable components. For many applications, you can design around these packaged systems as they stand—and thus reduce engineering time, lead time, and costs. In other instances, slight modifications of the modular units provide the basis for immediately available systems.

Get complete information on this latest Airborne development by requesting new Bulletin PS-5A. If you feel your requirements are unique and cannot be met with standardized units—however flexible—we still invite your inquiry. As mentioned, Airborne offers an extensive background in custom systems—for temperature control, servo control, and positioning.

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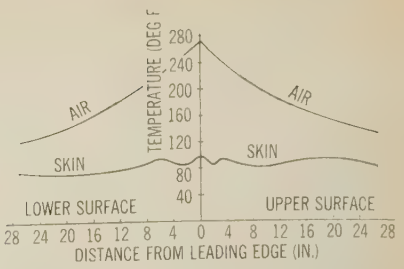

FIGURE 3: Predicted skin temperature distribution for intermediate wing station at 20,000 ft, 300 knots TAS, and +15 deg F ambient air temperature and assuming 20 microns volume-median drop size, 0.44 gm/m³ liquid water content, 170 pph primary air flow per foot of span, and 545 deg F supply temperature.

tion made on an IBM 704 computer.

The simplified analysis assumed a fully turbulent boundary layer from the leading edge, free-stream velocity, and a uniform surface temperature. The point-by-point analysis was made as exact as possible: Lockheed used the best available methods to find the chordwise velocity distributions, Eckert's wedge solution to calculate the laminar heat transfer, and local impingement data to determine the sensible heating; the boundary layer transition Reynolds number allowed for the effects of a favorable pressure gradient; F was reduced progressively to account for upstream evaporation; and conduction between inner and outer skins was taken into account.

The velocity distribution over an average wing section for the design icing condition was calculated from NASA data. From it, Lockheed then determined the heat transfer coefficient (*Fig. 2*). Its assumptions about the extent of laminar flow and the location of the boundary layer transition were based on relevant NASA data and on the results of our wind tunnel and flight icing tests.

The heat transfer rate corresponding to the internal temperature drop of the hot air depends on the temperature of the mixed air entering the double-skin passages and on the air flow in these passages. The latter in turn depends on a balance between the pressure rise in the mixing section and the pressure drop in the passages.

The mixed-air temperature is more difficult to calculate: The pas-

Anti-Icing Heat Balance

External Heat Load:

Q_{req} = convection + sensible heating + evaporation
$= h_o A_o(t_{sk} - t_{aw}) + MC_w(t_{sk} - t_w) + 2.9h_oA_oF(P_{sk} - P\infty)L_v/(P_{amb} - P_{sk})$,

where Q_{req} is heat required for evaporative anti-icing (in btu/hr per foot of span); h_o, external heat transfer coefficient (in btu/hr-sq ft-deg F); A_o, external heat transfer surface area (in square feet per foot of span); t_{sk}, skin temperature required for evaporation (in degrees F); t_{aw}, adiabatic wall temperature (in degrees F); M, water catch rate (in lb/hr per foot of span); C_w, specific heat of water, or 1 btu/lb-deg F; t_w, total temperature of atmospheric water (in degrees F); F, wettedness factor; P_{sk}, saturation pressure of water vapor at t_{sk} (in psia); $P\infty$, saturation pressure of water vapor at t_w (in psia); and P_{amb}, ambient static pressure (in psia).

For evaporative anti-icing, the water evaporation rate equals M, which in turn equals the last term of the above equation.

Passage Heat Supply:

$Q_{supp} = W_{pass}C_p(t_{mix} - t_{ex})$,

where Q_{supp} is heat supplied by passage air flow (in btu/hr per foot of span); W_{pass}, passage air flow (in pph per foot of span); C_p, specific heat of air, or 0.24 btu/lb-deg F; t_{mix}, mixed-air temperature at passage inlet (in degrees F); and t_{ex}, passage exit air temperature (in degrees F).

$W_{pass}C_p(dt_{air}) = h_i(t_{air} - t_{sk}(dx$,

where t_{air} is passage air temperature at any point (in degrees F) and h_i is heat transfer coefficient inside passage (in btu/hr-sq ft-deg F). By integration:

$(t_{ex} - t_{sk})/(t_{mix} - t_{sk}) = e^{-h_iA_i/W_{pass}C_p}$,

where A_i is passage heat transfer area (in square feet) and

$t_{mix} = (t_{bl} + \mu t_{plenum})/(1 + \mu)$,

with t_{bl} the bleed air temperature in the piccolo tube (in degrees F), μ the ejector entrainment ratio, and t_{plenum} the ejector secondary air temperature (in degrees F), which is equal to the leading edge plenum temperature and also to t_{ex}.

sage-exit, or plenum, temperature must first be found from the equation for t_{mix} (see *Table*). As the system is controlled thermostatically, the leading-edge plenum temperature is preset and the weight flow

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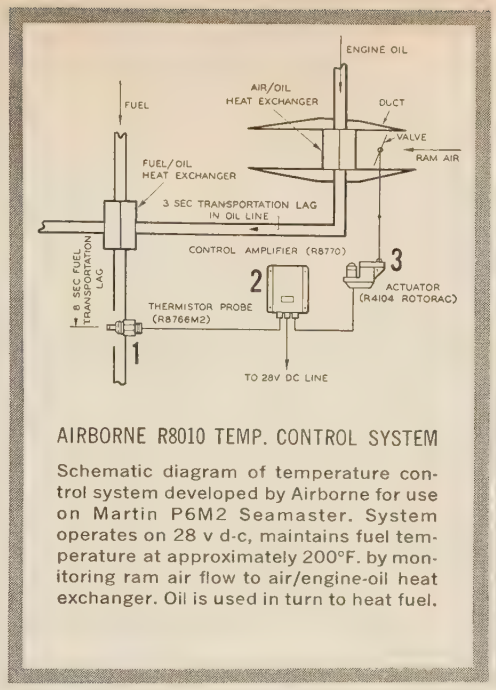

AIRBORNE R8010 TEMP. CONTROL SYSTEM

Schematic diagram of temperature control system developed by Airborne for use on Martin P6M2 Seamaster. System operates on 28 v d-c, maintains fuel temperature at approximately 200°F. by monitoring ram air flow to air/engine-oil heat exchanger. Oil is used in turn to heat fuel.

Airborne electromechanical system regulates jet fuel temperature

An integral part of each main engine installation on the Martin P6M2 Seamaster is an Airborne R-8010 custom-engineered temperature control system. By regulating air flow through a heat exchanger, this system maintains supply line fuel at 180-220°F.

As developed for the P6M2, the R-8010 system consists of a thermistor probe, a control amplifier and a rotary actuator. The probe (mounted in an MS10057-12 fitting) is in direct contact with the temperature-regulated fuel and presents to the control box a resistance which is proportional to fuel temperature. In response, the control box energizes the actuator to change the setting of a ram air intake valve, thus regulating volume of air flow through an air/fuel heat exchanger. This sensing and response continues until prescribed fuel temperature is attained, at which point the system reaches a state of electrical balance.

A fail-safe feature is also provided. In the event of power failure, a magnetic clutch in the actuator is released, permitting the air valve to be pushed open by the force of the ram air.

This application* on the P6M2 illustrates only one of many possible adaptations of the Airborne R-8010 system for temperature control functions on aircraft, missiles and related equipment—cabin temperature control, engine temperature control, temperature regulation of fuel, oil, electronic cooling packages, etc. If you have requirements in these areas, we will be happy to make a proposal. Contact any of our offices.

*Described in detail in new Bulletin PS-4A, available on request.

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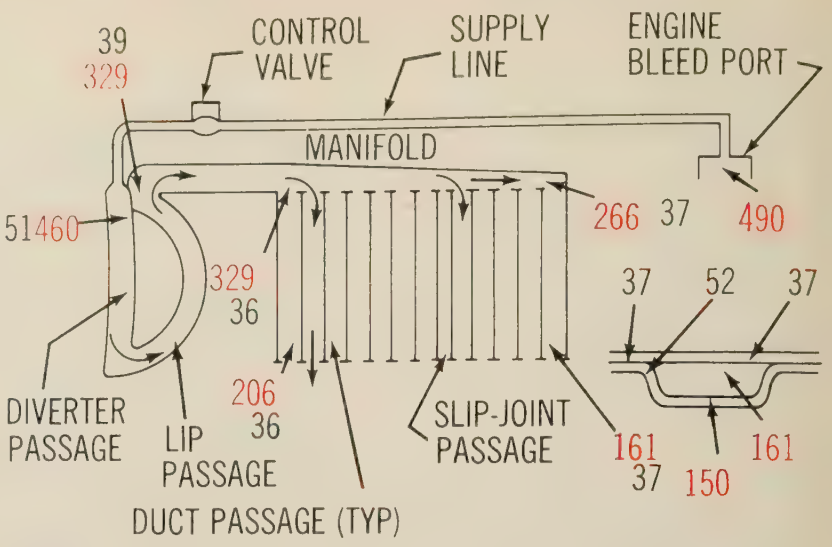

FIGURE 4: Predicted temperature distribution in the engine inlet duct at 20,000 ft, 300 knots TAS, and —22 deg F ambient air temperature and assuming 20 microns drop size, 0.14 gm/m³ liquid water content, and 750 pph air flow. Minimum skin temperatures (black) and air temperatures (color) are shown.

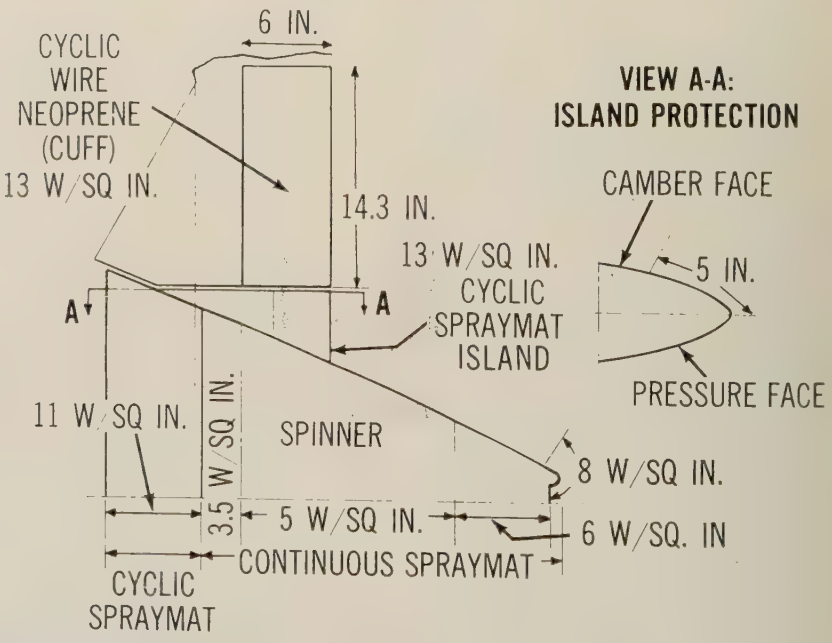

FIGURE 5: Power distribution in the prop and spinner ice protection system.

must be found through iteration.

In making all these calculations on its computer, Lockheed used the thermal-analyzer concept, with an equivalent network of resistors and condensers representing the thermal problem (*Fig. 7*). From the predicted distribution of surface and passage-air temperatures (*Fig. 3*), the local evaporation rate was found. This rate then was integrated over the heated area. The step-by-step analysis gave an evaporated rate equal to the water catch and resulted in the same required air flow as the simplified analysis.

For the analysis of the engine-

more on page 93

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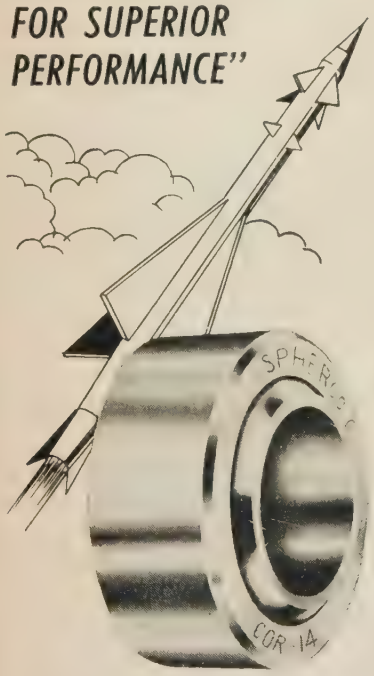

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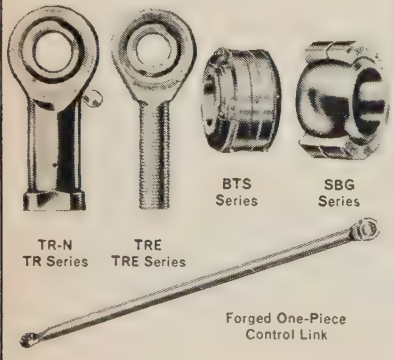
- Swage staking of 3-piece rod end
- Wide range of metals for races



WRITE FOR BULLETIN 257

SPHERCO
A PRODUCT OF SEALMASTER BEARING DIVISION STEPHENS-ADAMSON MFG. CO.
2 RIDGEWAY AVE. • AURORA, ILL.
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now there are 3

Honeywell, developers of the original VISICORDER Ultra Violet recording oscillograph principle, now brings you a third great Visicorder oscillograph . . . the

MODEL 1108 24-CHANNEL DIRECT-RECORDING VISICORDER OSCILLOGRAPH

H HONEYWELL

1

MODEL 906 VISICORDER

The original 8-channel Model 906 Visicorder was the first oscillograph to make use of the now-famous Ultra-Violet Visicorder recording principle, pioneered and developed by Honeywell. The 906 Visicorder was the first oscillograph to combine the high frequency response and writing speed of photographic-type oscillographs with the convenience of direct recording. Recent models incorporate time lines and grid lines, and record up to 14 simultaneous channels of data at frequencies from DC to 5000 cycles per second.

The 906 Visicorder is ideal for uses requiring up to 14 channels of data.

3

THE NEW MODEL 1108 VISICORDER OSCILLOGRAPH

Fitting ideally between the 14-channel 906 and the 36-channel 1012, the new 24-channel Model 1108 gives you direct writing Visicorder oscillography at the *lowest cost per channel.*

Like all Visicorders, the Model 1108 was designed from the base up to make the fullest use of the completely proven and unsurpassed Visicorder principle. The new 1108 also directly records at frequencies from DC to 5000 cycles per second at sensitivities comparable to photographic oscillographs. Like the Model 1012, the 1108 incorporates many automatic features and the years-ahead convenience of pushbutton controls.

The Model 1108 Visicorder, the most modern intermediate-size recording oscillograph on the market today, is ideal for intermediate uses requiring up to 24 channels of data.

2

MODEL 1012 VISICORDER

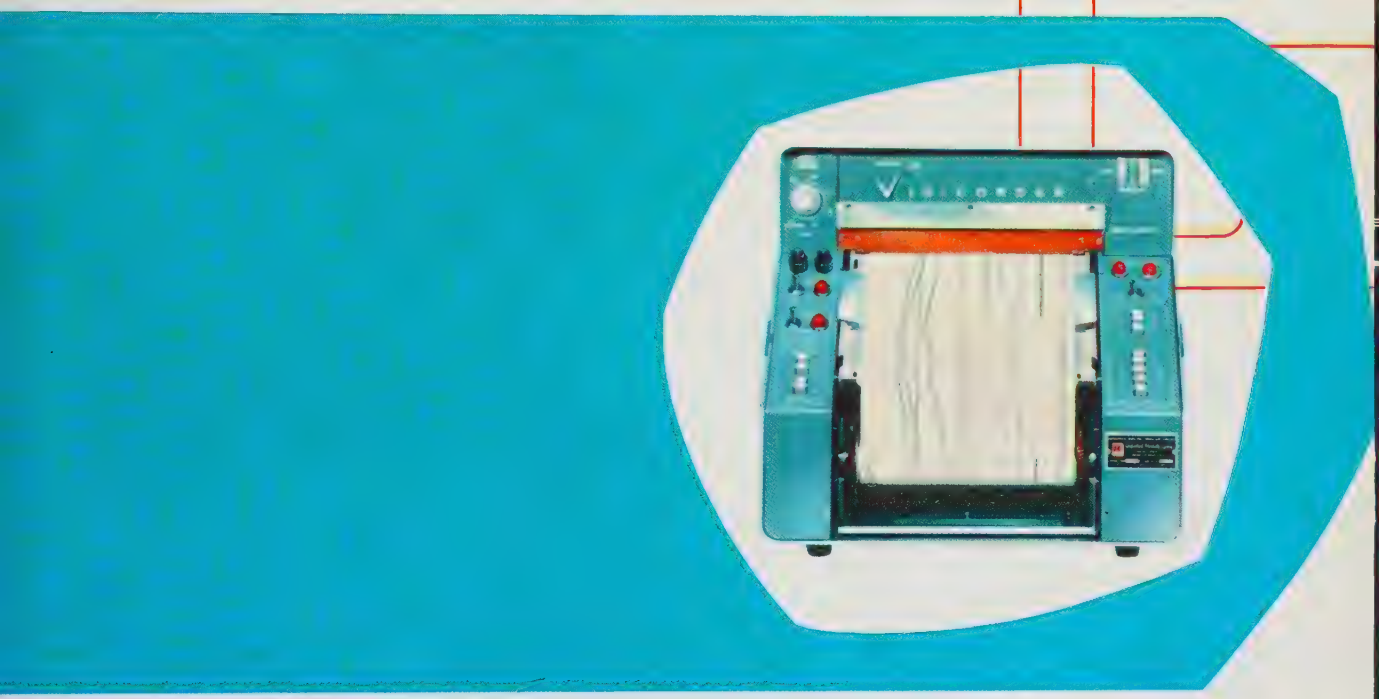
The Model 1012 Visicorder is the most versatile and convenient oscillograph ever devised for converting as many as 36 simultaneous channels of dynamic data into immediately-readable records. Like other Visicorders, the 1012 permits monitoring the information at the recording point as it goes on the record. It also records at frequencies from DC to 5000 cps.

The Model 1012 Visicorder, with its conveniences and broad capacities, is ideal for large-scale uses where up to 36 channels of data are required.

NEW MODEL 1108 VISICORDER provides the ultimate in imme

unlimited variety of applications.

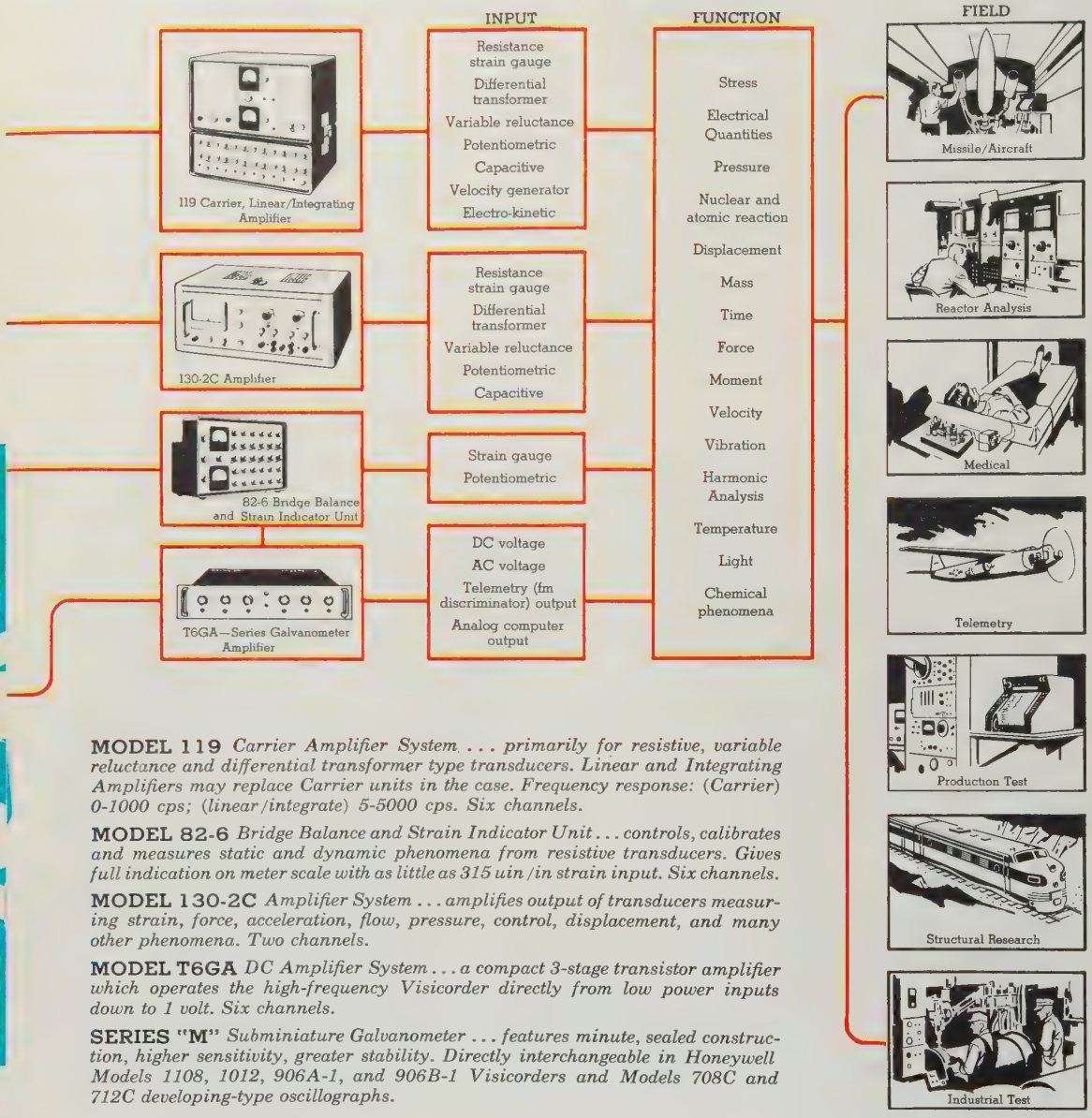
The Model 1108 may be used in direct connection with many types of transducers where high frequency recordings are not required. Or it may be teamed with various types of amplifiers where high-frequency—high amplitude readout is desirable. A broad selection of galvanometers with a wide variety of sensitivities and frequencies is available. A schematic diagram designed to suggest sample hookups for various applications—with and without amplification—appears at lower right, and demonstrates the wide variety of uses to which this one recording system may be put.



EASY PAPER LOADING . . . *Paper supply assembly swings forward, supply roll drops easily into place. No threading required.*

CONVENIENT ACCESS . . . *Covering panels on instru cleaning of optical components, calibrating timer, and to se REAR VIEW shows rear-panel input connectors.)*

diate, convenient readout of data in an



MODEL 119 *Carrier Amplifier System . . . primarily for resistive, variable reluctance and differential transformer type transducers. Linear and Integrating Amplifiers may replace Carrier units in the case. Frequency response: (Carrier) 0-1000 cps; (linear/integrate) 5-5000 cps. Six channels.*

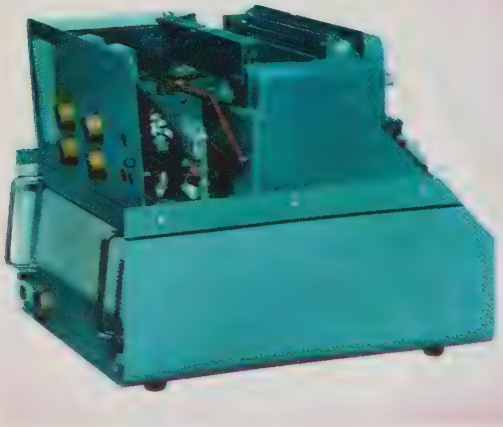
MODEL 82-6 *Bridge Balance and Strain Indicator Unit . . . controls, calibrates and measures static and dynamic phenomena from resistive transducers. Gives full indication on meter scale with as little as 315 uin/in strain input. Six channels.*

MODEL 130-2C *Amplifier System . . . amplifies output of transducers measuring strain, force, acceleration, flow, pressure, control, displacement, and many other phenomena. Two channels.*

MODEL T6GA *DC Amplifier System . . . a compact 3-stage transistor amplifier which operates the high-frequency Visicorder directly from low power inputs down to 1 volt. Six channels.*

SERIES "M" *Subminiature Galvanometer . . . features minute, sealed construction, higher sensitivity, greater stability. Directly interchangeable in Honeywell Models 1108, 1012, 906A-1, and 906B-1 Visicorders and Models 708C and 712C developing-type oscillographs.*

ument are readily removable for easy access to lamp, vice other assemblies. (THREE-QUARTER

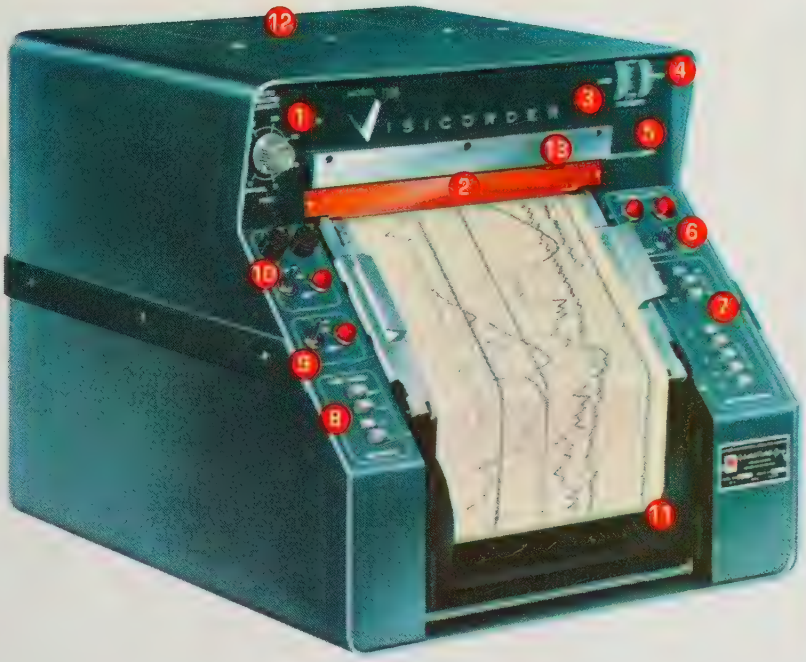


EASY GALVANOMETER ADJUSTMENT . . . *provided through top panel. No clamping or locking is required. Galvanometer spots may be observed at recording point while adjustment is being made.*

MODEL 1108 VISICORDER

adds still more versatility to the Honeywell family of direct recording oscillographs.

Designed to the utmost standards of customer convenience, high-frequency and high sensitivity recording, and reliable, accurate performance, the Model 1108 continues the long-standing tradition of Honeywell leadership through creative engineering. Examine the diagram below for feature-by-feature evidence of this leadership.



3

FEATURES OF THE 1108

General Features

1. **AUTOMATIC RECORD LENGTH CONTROL** . . . *adjustable from 1 to 25 feet . . . indicator shows amount of pre-set record length remaining.*
2. **VISIBLE RECORDING POINT** . . . *galvanometer spots may be monitored through amber screen as they record.*
3. **GRID LINE INTENSITY CONTROL** . . . *manually adjustable to compensate for exposure at various record speeds. (Grid line spacing: 0.1 inch; 5th line accentuated. Custom grid spacings on special order.)*
4. **GALVANOMETER SPOT INTENSITY CONTROL** . . . *off, on, and manually adjustable to control sharpness of galvanometer traces at various record speeds and writing speeds.*
5. **RECORD NUMBERING** . . . *Four-digit resettable record-number counter photographed at start of each record. Flash-tube type; may also be used as event marker.*
6. **RECORD DRIVE CONTROL and INDICATOR** . . . *"Forward" for recording; "reverse" for closer study and analysis of data after recording has been made. Indicator signal light turns off if recording is not taking place.*
7. **RECORD SPEED INDICATOR**, *pushbuttons for 5 speeds plus 3 range pushbuttons give you 15 separate speeds. Speeds may be changed during operation. Positive clutches, no gear meshing.*
8. **TIME LINE SYSTEM** . . . *Electronic flash type, instant warmup. Three selectable intervals: 1, .1, and .01 seconds. No optical parallax. May also be operated from external signal and in multiplex.*
9. **RECORDING LAMP ON-OFF CONTROL AND INDICATOR**
10. **POWER ON-OFF CONTROL AND INDICATOR**
11. **RECORDING PAPER CAPACITY** . . . *8" x 200 feet of standard-weight paper; 350 feet of thin base paper. Take-up integral with record-drive system.*
12. **GALVANOMETERS** . . . *access through top panel. Accepts up to 24 Series M Subminiature galvos, plus 4 static reference galvos. Directly interchangeable among Honeywell Models 906A-1, 906B-1, 1012, 700C oscillographs.*
13. **PAPER KNIFE** . . . *manually operated.*

Other Features

TRACE IDENTIFICATION . . . *at 45° slope, 1/32" width, interrupting galvos in sequence on approximately 8" spacing.*

OPTICAL ARM . . . *11.8 inches (30cm) standard in all Honeywell oscillographs.*

LAMP AND CIRCUIT . . . *High-pressure mercury vapor lamp. Automatic starting.*

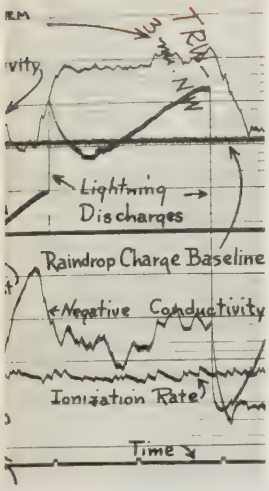
REMOTE OPERATION . . . *Control circuits provided for remote operation.*

INPUT POWER . . . *105-130 volts; 60 cycle; 7 amps. 50 and 400 cycle models also available.*

MOUNTING . . . *Table and rack. Shock or vibration mounting using available accessories.*

open this page

TYPICAL USES OF THE VISICORDER

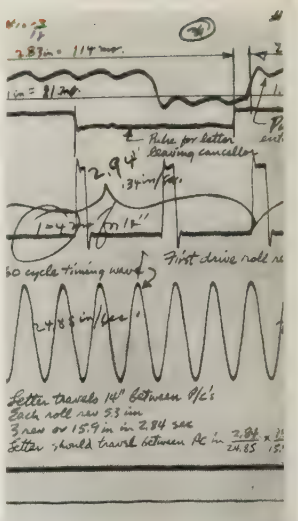


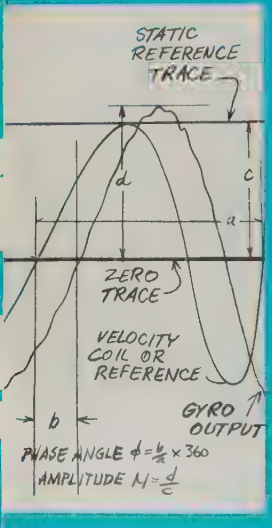
In weather research . . .

This Visicorder record gave U.S. Weather Bureau scientists immediate readout of thunderstorm data taken at Mt. Washburn in Yellowstone National Park. As the storm system passed, the Visicorder recorded positive and negative air conductivity, rate of ionization of air, raindrop charge, corona discharge current from an insulated tree and a 4′ x 6′ grass plot, times of camera exposure photographing droplet size and electrical charge, atmospheric potential gradient, and time.

In development test . . .

This directly-recorded Visicorder record shows a canceller test of letters through a new mail-handling machine developed by Emerson Research Laboratories for the U.S. Postoffice Department. The Visicorder test took only 3 hours to solve a 3-week problem: why letters, travelling at the rate of 30,000 letters per hour, changed speed as they went through the machine. (Constant speed is necessary to register cancellation on the stamp every time.) Motor speed variations, belt slippage, and letter slippage in the drive rollers were responsible. A synchronous-drive motor, a timing belt drive, and a better grade of rubber in the drive rollers were added to solve the problem at a vast saving in engineering time.



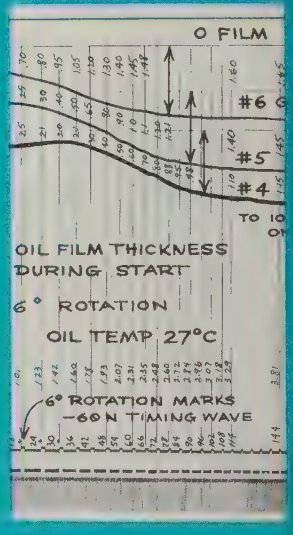


In production . . .

This comparison test of a production gyroscope was directly recorded by a Visicorder oscillograph in the test department of the Whittaker Gyro Division of Telecomputing Corporation, Van Nuys, California. The record shows how the Visicorder compares controlled angular velocities as a reference base to simultaneously-recorded variables, and how a dual static reference trace galvanometer simultaneously establishes a base line and a calibration line on the chart.

Industrial design . . .

This Visicorder record made by design engineers at Westinghouse measured oil film thicknesses on the bearing pads of a 67,500 kilowatt water wheel generator supplied for Chief Joseph Dam at Bridgeport, Washington. In these tests, oil thicknesses encountered by the leading edge, center, and trailing edge of the bearing were found to be within the limits of safety as predicted by engineering assumptions.



OTHER USES of the Model 1108 Visicorder . . . as a direct readout unit IN RECORDING AND MONITORING SYSTEMS . . . IN MISSILE AND ENGINE ANALYSIS for test stand recording . . . for analog recording OF TELEMETERED SIGNALS . . . IN CONTROL to monitor reference and error signals . . . IN NUCLEAR TEST to record temperatures, pressures, impacts, etc. . . . IN LABORATORIES for all purpose analysis . . . IN PRODUCTION for final dynamic inspection . . . IN COMPUTING for immediately-readable analog records . . . IN PILOT COMPONENT TESTS for rapid evaluation of prototypes . . . IN ALL TESTS which are non-repetitive in sequence, making oscilloscopes impractical.

Honeywell

Industrial Products Group

For further information including prices and delivery, write Minneapolis-Honeywell Regulator Company, Industrial Products Group, Heiland Division, 5200 E. Evans Ave., Denver 22, Colorado.

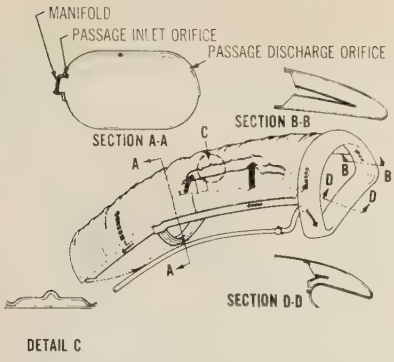


FIGURE 6: Engine inlet duct anti-icing system.

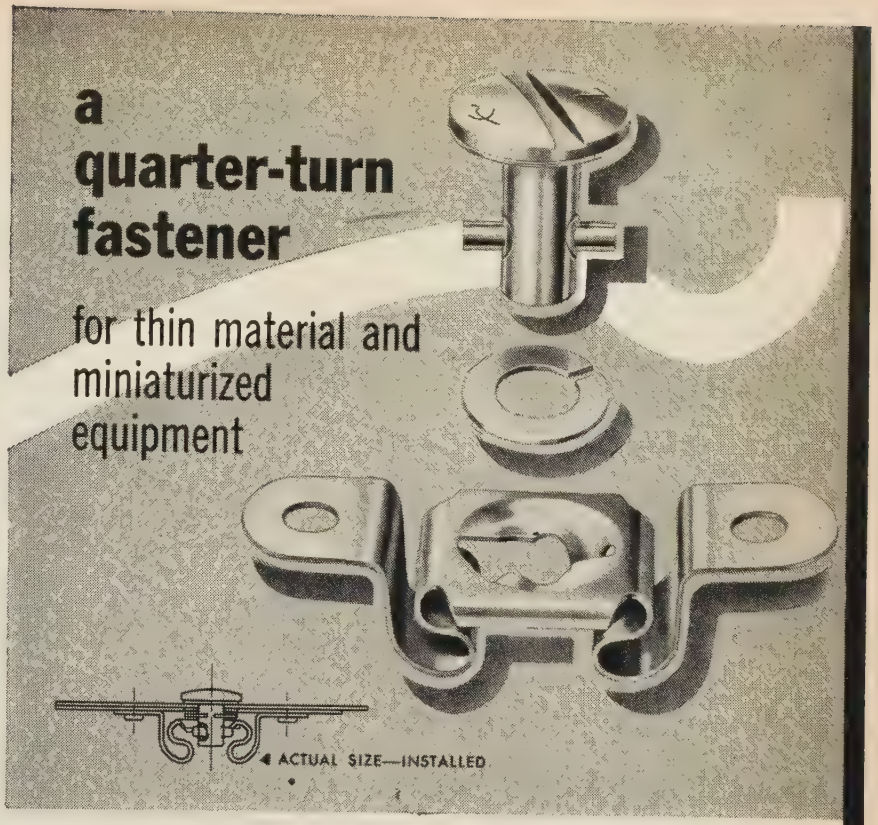
inlet-duct anti-icing system, Lockheed used the same energy relationships as for the airfoil system. The system keeps the coldest part of the heated area of the inlet duct just above the freezing point at 300 knots TAS and 20,000 ft on a –22 deg F day. The stainless steel inlet duct shows a temperature gradient between its heated area and its indirectly heated portions between air passages. Lockheed therefore used the thermal-analyzer concept to find bleed air flow requirements and temperature distribution (*Fig. 4*), allowing for temperature drops from the bleed port to the duct lip and along the distribution manifold (which is an integral part of the duct wall).

Prop and spinner ice protection, Lockheed found, had to extend only to the cuffs, spinners, and islands. Ice buildup is worst in these areas, and uncontrolled ice shedding might endanger the engine. Flight experience has shown that icing in the blade stations beyond the cuff has only negligible effects on prop balance and propulsive efficiency.

All the prop and spinner deicing elements operate on a cycle of 15 seconds on and 115 seconds off. The cuffs are protected by wire-embedded Neoprene elements operating at 13 W/sq in.; on the island platforms and the aft spinners, Spraymat at 13 and 11 W/sq in., respectively, is used.

The forward area of the spinner is heated continuously by Spraymat elements (*Fig. 5*) to provide an average surface temperature of about 35 deg F down to zero deg F. Actually the elements are adequate down to at least —5 deg F—apparently because of the heat

more on next page



CAMLOC *low cost/light weight*

5F series

Camloc's new small, lightweight 5F Series features high strength-weight ratio plus the quick-operating advantages of a ¼-turn fastener... in a size and weight that offers new design possibilities to original equipment manufacturers! Particularly adaptable to thin materials and miniaturized equipment like airborne electronics, small electro-mechanical and computing devices and communications components. Ideal for attaching lightweight components in "packaged" equipment or for holding access panels on everything from washing machines to radar units.

Offered in many different head styles. Complete specifications will be sent to you on request.

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generated by the prop mechanism within the spinner.

The compressor bleed air for the Electra fuselage ice protection system is distributed through a manifold located next to the front wing beam and extending from one outboard nacelle to the other (*Fig. 1*). It is supplied to the manifold through shutoff valves at each nacelle and delivered to three airfoil leading-edge sections in each wing as well as to an empennage supply duct. Its flow into the wing sections and the empennage is thermostatically regulated by seven pneumatically operated combination regulators and shutoff valves.

Each leading-edge heat transfer section consists of a stainless steel manifold duct of ¾-1¾ in. diameter that is fitted with 40 0.05-in. nozzles per foot. These "piccolo

more on page 97

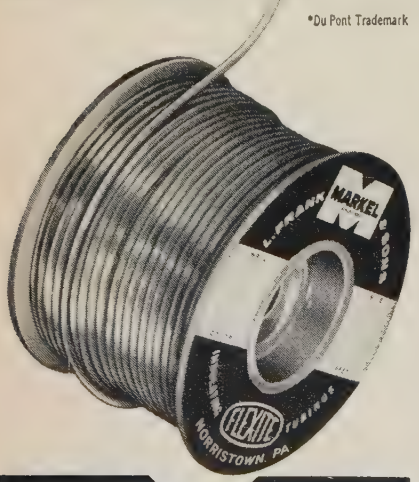
For Excellence

TEFLON

TUBING

Teflon* tubing is well known to be chemically inert, to resist abrasion, and to stay flexible at extreme temperatures.
For mechanical, chemical, aeronautical and electrical uses, extruded tubings of Teflon and other plastics bearing the FLEXITE trademark assure you dependable performance through precision manufacturing by MARKEL—with whom excellence has been a credo since 1922. Name your need; let Markel send samples and data.

*Du Pont Trademark



MARKEL
SINCE 1922

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Norristown Pennsylvania

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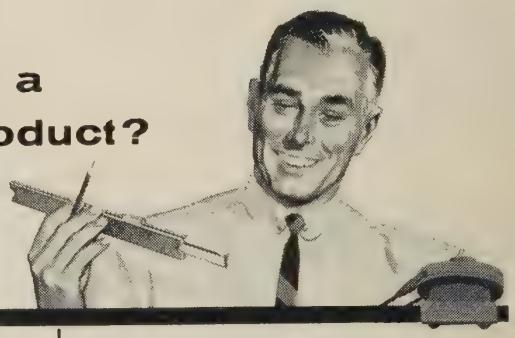
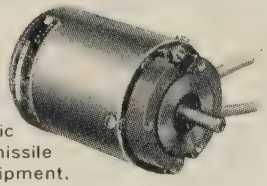
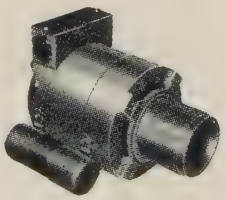
Developing a motor-driven product?

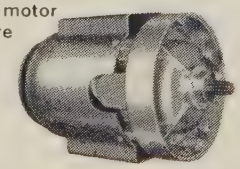




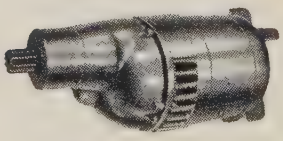
Lamb® six-pole 400 cycle AC motor for electronic cooling in missile control equipment. Frame 1 11/16 x 1¼



Lamb® four-pole capacitor start induction run motor with special bracket for telephone toll ticket process machine. Frame 4½ x 2¼



Lamb® totally enclosed fan-cooled explosion-proof motor for high pressure grease gun. Frame 3 11/16 x 2¼



Lamb® heavy duty three-stage gearmotor for pipe threaders. Frame 4⅜ x 2¼

Here's a way to make sure you get The Right Motor

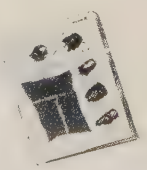
When you reach the point in the development of a new product where you are ready to discuss the motor, we shall welcome an opportunity to carefully study your motor problem and try to find an existing motor design that will do the job.

If the *right* motor is readily and economically available, we shall tell you. Our interest is in devoting engineering man-hours to the solution of design problems—not in duplicating development work which already has been done.

Because of this approach and because of our motor design and development experience—44 years in the small motor field—we can help your company obtain the *right* motor . . . at the most favorable cost.

THE LAMB ELECTRIC COMPANY • KENT, OHIO
A Division of American Machine and Metals, Inc.

Lamb Electric
SPECIAL APPLICATION FRACTIONAL HORSEPOWER MOTORS



Write for your copy... 8-page folder describes these and other Lamb Electric motors.

In Canada: Lamb Electric
Division of Sangamo Company Ltd. • Leaside, Ontario

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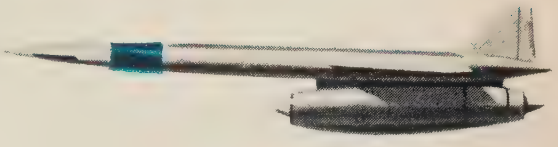
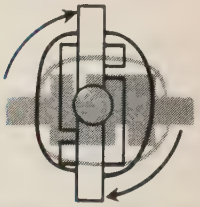
Pedigree of a Hound Dog



The guidance and control system of America's HOUND DOG missiles—best of breed—has a pedigree 13 years long. Created by Autonetics, the HOUND DOG's inertial autonavigation system sends this supersonic air-to-surface missile from mother-ship to target anywhere in the world, in any weather. Equipped with an invulnerable sense, HOUND DOG extends the retaliatory effectiveness of SAC's B-52G bombers by hundreds of miles.

Against a 13-year background of blue-ribbon winners, Autonetics is now producing in quantity and at low cost the N5G autonavigator. This is the pedigree that makes the GAM-77 HOUND DOG missile performance "best in show."

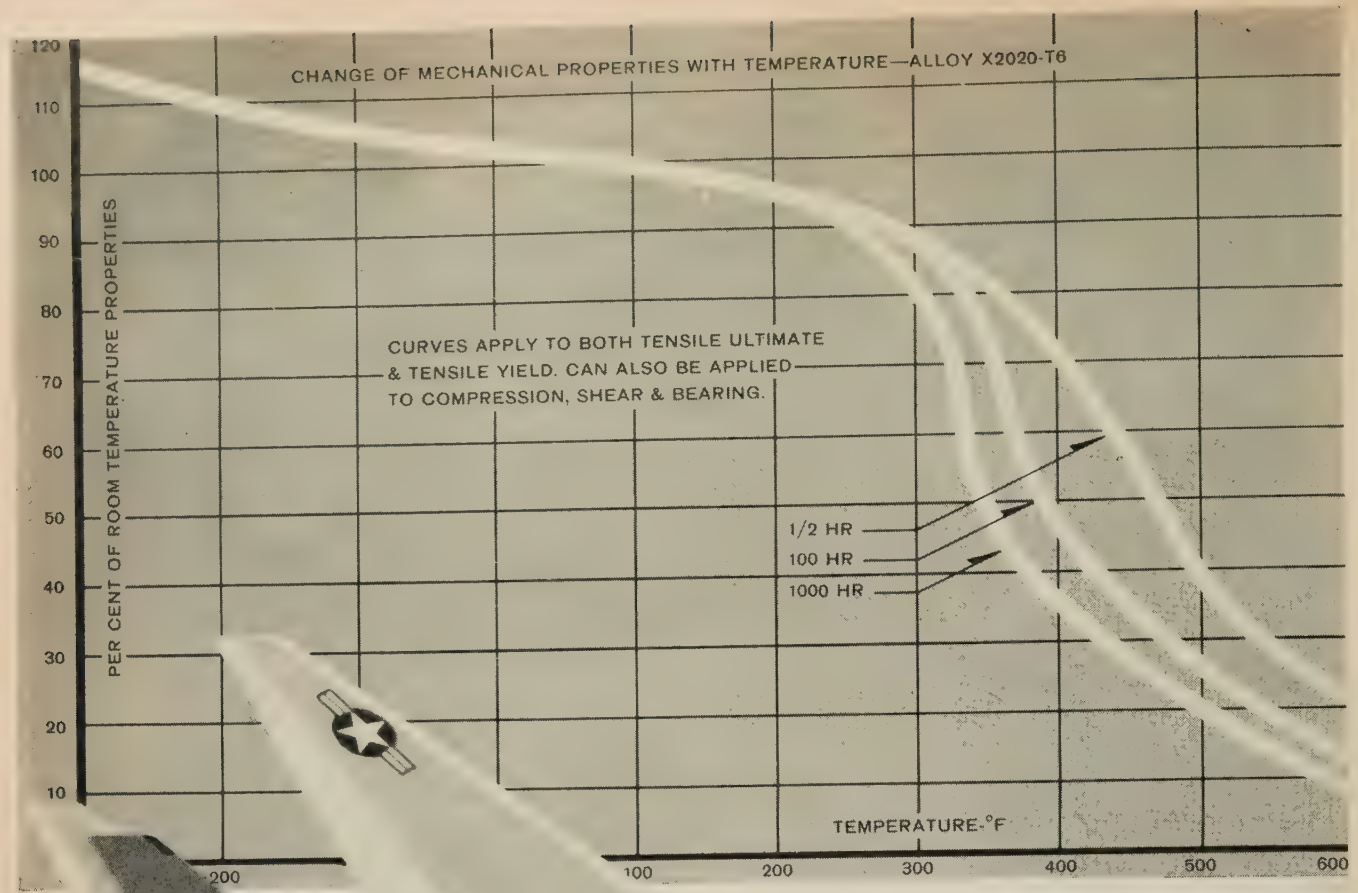
DID YOU KNOW?...



At Autonetics, navigation gyros are made so precisely that it would take over 40 years for one to precess one complete revolution.

Inertial navigation by Autonetics

A DIVISION OF NORTH AMERICAN AVIATION, INC., DOWNEY, CALIFORNIA • REGIONAL OFFICES: WASHINGTON, D.C. AND DAYTON, OHIO
INERTIAL NAVIGATION / ARMAMENT CONTROL / FLIGHT CONTROL / COMPUTERS AND DATA PROCESSING



NORTH AMERICAN TRIMS VITAL POUNDS FROM VIGILANTE WITH ALCOA X-2020 ALLOY

THE EXCEPTIONAL high strength and stiffness of Alcoa's new lithium-aluminum alloy permit North American Aviation, Inc., to trim 168 lb from the Navy's A3J *Vigilante* weapon system. Substitution of X-2020 for the alloy previously used allows additional skin milling of the *inboard wings and horizontal stabilizers* to reduce thickness and weight.

ALL THE TENSILE properties of the widely known Alcoa 7075 are combined in this extraordinary new alloy together with three per cent lighter weight and a modulus of elasticity eight per cent higher. The moduli of elasticity in tension and compression at room temperature for X-2020 are 11,100 ksi and 11,400 ksi, respectively. This compares to 10,300 and 10,500 ksi for 7075.

ALTHOUGH THE *Vigilante's* highly supersonic speed does not utilize the high-temperature qualities of X-2020, North American regards the alloy's ability to retain its physical properties at 400°F as an important bonus in the event the aircraft is powered to greater future speeds.

IN ADDITION to its other attributes, North American found that X-2020 machines as readily as other aluminum alloys. X-2020 readily lends itself to the usual aircraft fabrication processes. It is now available in sheet, plate, extrusions, rolled rod and bar from Alcoa. For those pioneering metallurgists who wish to investigate other outstanding qualities of X-2020, Alcoa has facilities for experimental forgings.

FOR COMPLETE, up-to-date technical information and performance data, call your nearest Alcoa sales office or write Aluminum Company of America, 2027-M Alcoa Building, Pittsburgh 19, Pennsylvania.

Your Guide to the Best in Aluminum Value

ALCOA ALUMINUM

For exciting drama watch "Alcoa Presents" every Tuesday, ABC-TV, and the Emmy Award winning "Alcoa Theatre" alternate Mondays, NBC-TV

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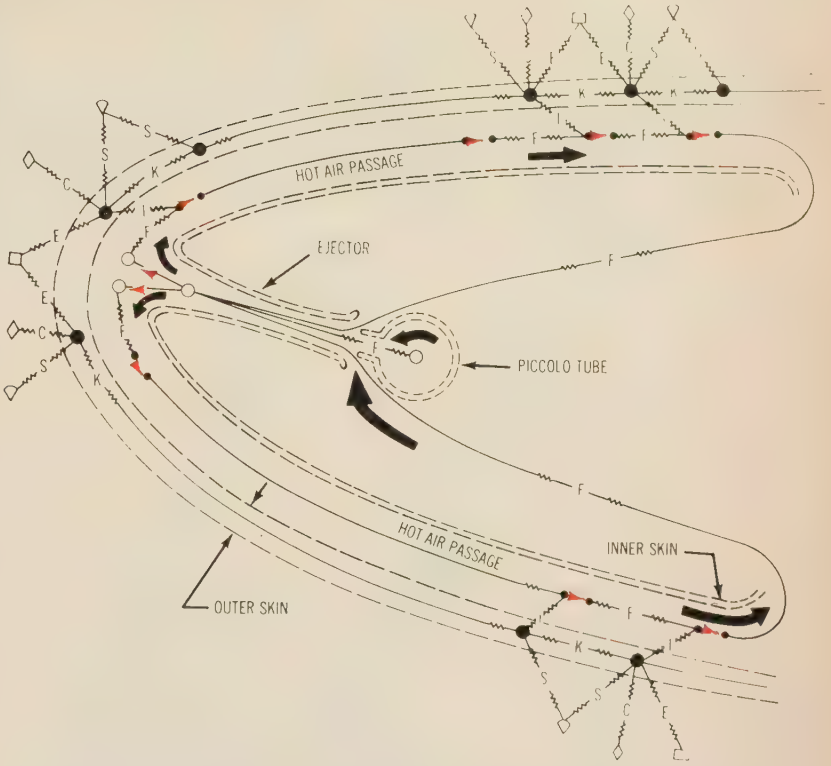

FIGURE 7: Analog circuit for skin temperature distribution. The black dots are nodes; the colored arrowheads are cathode follower points indicating the flow direction, and the black arrows show the direction of the air flow. The letters indicate resistors for air enthalpy change (F), skin conduction (K), internal convection (I), external convection (C), evaporation (E), and sensible heating (S).

tubes" act as distributed primary nozzles for a continuous jet-pump recirculation system supplying air to the surface heat transfer passages. They make it possible to cool the bleed air from 550-600 deg F to a mixed temperature of 300 deg F that is compatible with the Electra's aluminum structure. Sealed connections between the hot duct and the cooler structure are unnecessary, and a sliding or floating duct support can be used to allow for thermal expansion.

Thermostatic sensing is applied at the exit of a typical heat transfer passage. This design has the advantages of simplicity and reliability over the theoretically preferable scheme of skin temperature regulation.

Because of the large periodic temperature variation in the high pressure air distribution ducting, provisions for relative motion between ducting and airframe had to be made. The duct system was designed so as to provide axial tension in the duct walls. In this way, we avoided column-type instability, which would have required heavy retaining bracketry.

To get the flexibility needed for tension loading, Lockheed used bellows sealed, T-type slip joints at the outboard ends of the wing manifold duct, Y-type deflectable duct legs at the intersection of the fuselage and wing ducts, and omega loops in the aft empennage duct. To control heat dissipation from the ducting, prefabricated, steel-enclosed insulation is installed over all high temperature ducts in wing and fuselage.

The lip and the exposed internal surface of the engine inlet duct are protected by a continuous-flow bleed-air system (*Fig. 6*). These surfaces are made of steel, so that the bleed air can be used directly at 600 deg F. A simple orifice and an electric shutoff valve control the air flow. The inlet-lip heating passage is in series with the passages for the internal surface. It receives the hot air first and therefore provides evaporative anti-icing; in the duct, anti-icing then is 'running wet."—End

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You get more than just 16 ounces of metal in every pound of Alcoa® Aluminum. Here are eight important unmatched values that go with it:

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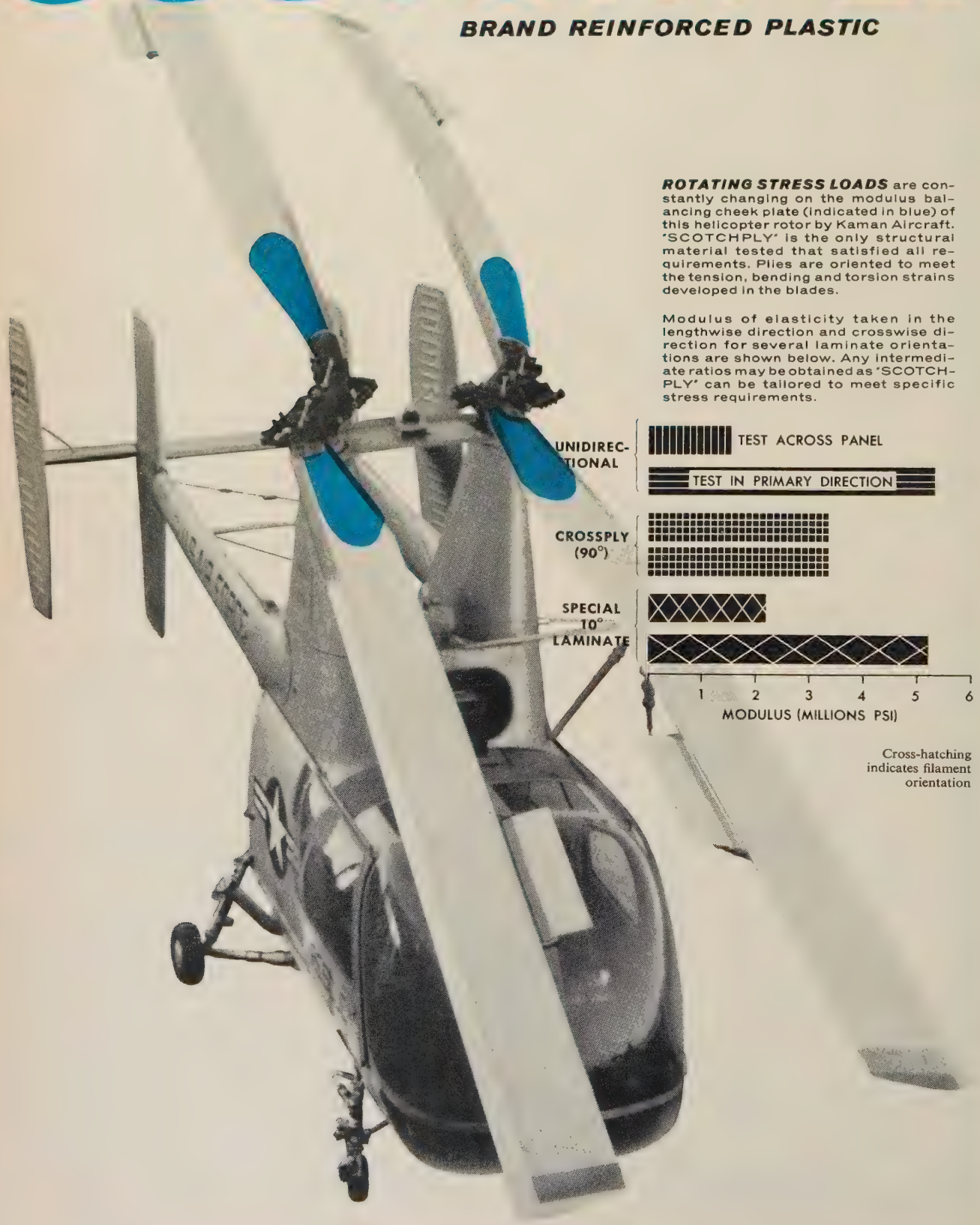
SCOTCHPLY®

BRAND REINFORCED PLASTIC



ROTATING STRESS LOADS are constantly changing on the modulus balancing cheek plate (indicated in blue) of this helicopter rotor by Kaman Aircraft. "SCOTCHPLY" is the only structural material tested that satisfied all requirements. Plies are oriented to meet the tension, bending and torsion strains developed in the blades.

Modulus of elasticity taken in the lengthwise direction and crosswise direction for several laminate orientations are shown below. Any intermediate ratios may be obtained as "SCOTCHPLY" can be tailored to meet specific stress requirements.

Cross-hatching indicates filament orientation

STRENGTH-TO-WEIGHT RATIO TOPS ALL STRUCTURAL MATERIALS

Strength/weight and other exclusive properties result from customized orientation of continuous, non-woven glass filaments*

What's the big difference between "SCOTCHPLY" and other pre-impregnated reinforced plastics? Only "SCOTCHPLY" BRAND Reinforced Plastic has continuous, non-woven glass filament* reinforcement.

Here are the superior properties that result:

★ ***UNMATCHED INDIVIDUAL PLY STRENGTH***—each ply consists of *continuous straight* filaments in parallel alignment, not crimped or woven.

★ ***HIGHEST DEGREE OF TAILORABILITY***—individual plies may be oriented to meet specific stress requirements; reinforcement (weight and bulk) is not wasted in directions or regions of low stress. This *degree* of tailorability is not possible with other reinforced plastics using woven cloth or short strand reinforcement.

This duo of exclusive advantages combines to give "SCOTCHPLY" an unequalled strength-to-weight ratio and superior fatigue properties.

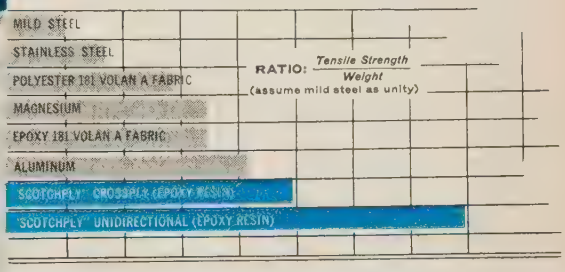
Sold in uncured rolls or sheets, "SCOTCHPLY" Reinforced Plastic is a moldable, laminated plastic consisting of a mechanically controlled ratio of resin to reinforcement*. Heat and low pressure in matched metal dies, vacuum or pressure-bag molding cure it into rigid form.

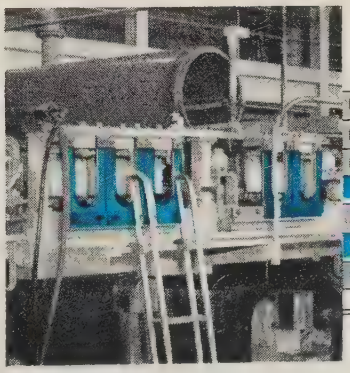
For complete information and technical service, write on your letterhead to Dept. XAA-129, Reinforced Plastics Division, 3M Co., 1210 University Ave., St. Paul 4, Minn.

**Other available filaments: nylon, asbestos and other ablation materials. Epoxy, phenolic and other resin systems are available.*

EXTREMELY HIGH TENSILE STRENGTH and light weight are essential in this battery case by Prewitt Aircraft for a classified missile. By proper orientation of reinforcing filaments, "SCOTCHPLY" provides maximum strength where strength is needed to withstand tremendous acceleration loads.

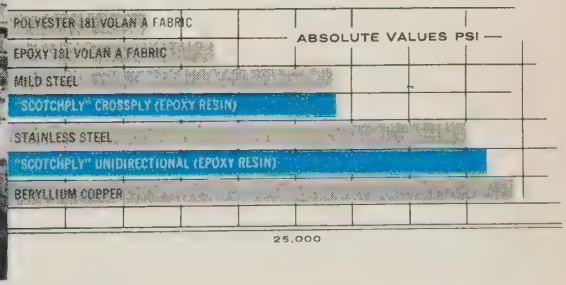
Tensile strength-weight ratios





FLEXURAL FATIGUE failure of metal Fourdrinier springs resulted in costly breakdowns on this paper machine manufactured by Rice Barton Corporation. Now Fourdrinier springs of "SCOTCHPLY"—tailored to the application—do the job.

Flexural-fatigue strength @ 2 x 10^6 cycles



"SCOTCHPLY" IS A REGISTERED TRADEMARK OF THE 3M CO., ST. PAUL 6, MINN. EXPORT: 99 PARK AVE., NEW YORK 16, N. Y. CANADA: LONDON, ONTARIO

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3M COMPANY

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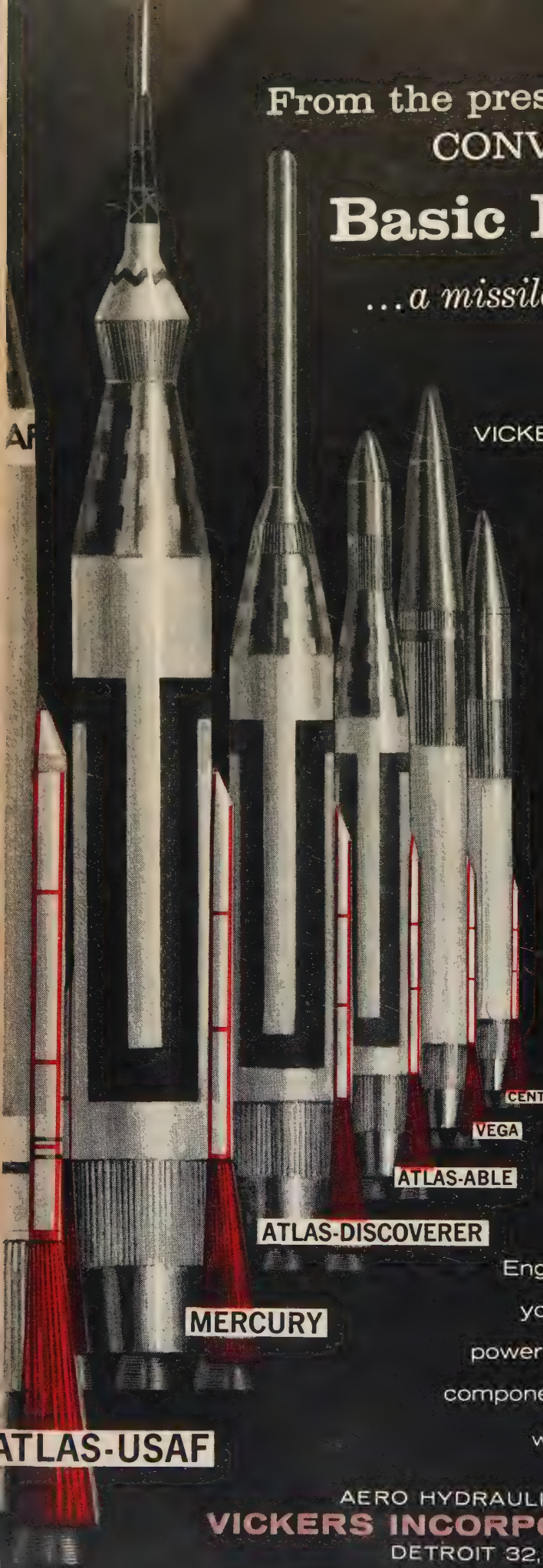
...a missile booster for peaceful scientific space exploration



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VICKERS, as a result of its participation in missile and spacecraft programs, has developed cryogenic, hot gas and other types of auxiliary power systems. Also available: electrical generating systems, actuator systems, and miniaturized power packages with integral controls.

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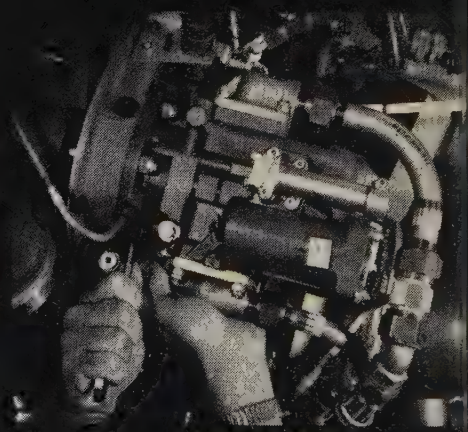

Vickers Pump Being Installed on Atlas

AERO HYDRAULICS DIVISION
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division of
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"Light foot quantizer"

for highly precise time measurement

To get reliable speed and acceleration data from the tests of today's high speed vehicles, we need far more accurate measuring systems than we've had in the past. Here's a design analysis of a novel measuring device that has helped to meet the accuracy requirements of Mach 4+ rocket sled tests.

by M. A. Alexander and Douglas Epps, Vice President-Engineering & Project Engineer, Computer Equipment Corp.*

MEASURING the speed and acceleration performance of modern aerospace equipment calls for devices with extraordinarily high time resolution. Take, for example, the measuring gear for the supersonic test sled track at Edwards AFB, Calif. This equipment required scaling circuits with 50 times better resolution than had been achieved in any previous comparable installation.

A careful evaluation of this requirement by Computer Equipment led to the invention of the "light foot quantizer" (*Fig. 1*). This device performs basic quantizing functions dependably and accurately, using techniques not previously applied in electronic quantizing systems.

The basic measuring equipment is included in a "space-time Quantizing system" using space-time coils placed along the sled track. The coils are energized by magnetic material mounted on the sled. A voltage pulse is generated by each coil as the sled passes it.

The pulse is transmitted to the space-time quantizer, which processes it, determines the time interval between pulses, and transmits—in real time—coded digital data to a tape recording system. (The code is generated in the language of the analysis computer.)

As the sled travels at Mach 4 and faster, the interval between pulses is small and hard to measure

more on next page

* Computer Equipment Corp., 1931 Pontius St., Los Angeles 35, Calif.

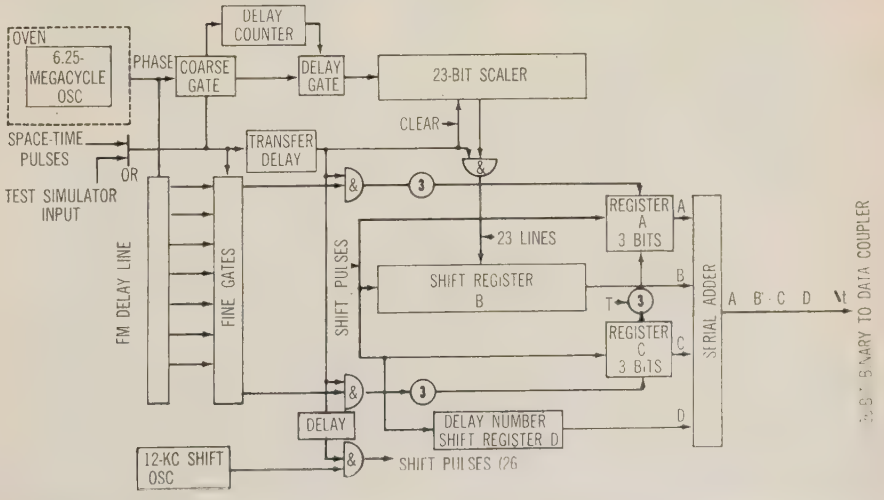

FIGURE 1: Light foot quantizer, invented by Computer Equipment, has a resolution of 20 millimicrosec or better.

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accurately. Scaling circuits in the past used a counting rate of one megacycle for a resolution of one microsecond. The light-foot quantizer has a resolution of 20 millimicrosec, which may be reduced to five millimicrosec without difficulty.

A light foot is the time it takes light to travel one foot and equals 1.017 millimicrosec. This is close enough to one millimicrosec to allow us to say that, for practical purposes, one light foot equals one millimicrosec. The light-foot quantizer then is a quantizing device with a resolution capability in the millimicrosecond region.

What are the physical aspects of a mechanical system capable of such precise time measurement? The average velocity of the sled between two marks is given by:

(1) $$v = d/t,$$

where d is the distance between the marks and t the time it takes the sled to cover d. The error Δv in v is the result of errors in both d and t. It can be found from the partial differential relationship:

(2) $$\Delta v = (\partial v/\partial d)\Delta d + (\partial v/\partial t)\Delta t,$$

or, in relative terms:

(3) $$\Delta v/v = \partial v \Delta d/\partial dv + \partial v \Delta t/\partial tv.$$

From *Equation 3*, it follows that:

(4) $$\Delta v/v = \Delta d/d - \Delta t/t = \Delta d/d + f\Delta t,$$

where f is the frequency of the mark signals and the reciprocal of t. The change of sign takes care of the possibility of compound error.

Let's assume that, in the system under discussion, $\Delta d/d$ is on the order of ± 0.001 in 10 ft and Δt is ± 20 millimicrosec. If the accuracy of the average velocity measurement is specified as one part in 20,000, limiting value of f can be found from $\Delta v/v = 50/10^6$, $\Delta d/d = 8.3/10^6$, and $\Delta t = 20/10^9$ sec. From *Equation 4* we derive:

(5) $$f = (1/\Delta t)\,(\Delta v/v - \Delta d/d) = 41.7/20 \text{ cps} \approx 2 \text{ cps}.$$

Or we may calculate the accuracy to which the blades can be set if we limit the mark frequency to 1000 cps. Using $\Delta v/v = 50/10^6$ and $t = 20/10^9$ sec, we get:

(6) $$\Delta d/d = \Delta v/v - f\Delta t = 50/10^6 - 1000 \times 20/10^9 \approx 0.004 \text{ in } 10 \text{ ft}.$$

We can assume that acceleration will be measured by some form of computational "curve fitting" derived from the velocity data. What then will be made the magnitude of the error that must be expected?

Acceleration is given by:

(7) $$a = v_2 - v_1/t,$$

where v_2 is terminal velocity and

more on page 104

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SPECIAL REPORT ON STEP-SERVO MOTORS:

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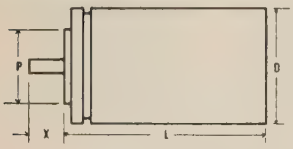
GENERAL SPECIFICATIONS FOR STEP-SERVO MOTORS



I. M. C. Type	Dim. in Inches D	L	P	X	Max. Rotor Inertia Gm-Cm²	Min. Stall Torque Oz.-In.	Ohms Per Phase
005-801	.500	1.20	.375	13/32	0.20	0.4	120
008-801	.750	1.23	.500	11/32	0.20	0.6	120
9708-024	.750	1.14	.500	11/32	0.65	0.8	120
011-801	1.062	2.00	.625	3/8	1.50	1.8	120
011-859	1.062	1.36	.625	3/8	0.65	1.4	120
9711-056	1.062	1.78	.625	3/8	2.50	1.2	300
9715-001	1.437	1.75	.875	3/8	2.50	1.8	120
023-801	2.250	1.75	2.00	5/8	5.0	3.0	120

Information regarding cost, delivery, or additional technical data, as well as information on synchro components and solenoids, is available when requested on your company letterhead.

Induction Motors of California

DIVISION OF
IMC MAGNETICS CORP., N.Y.
6060 Walker Avenue, Maywood, California
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Representatives in principal cities

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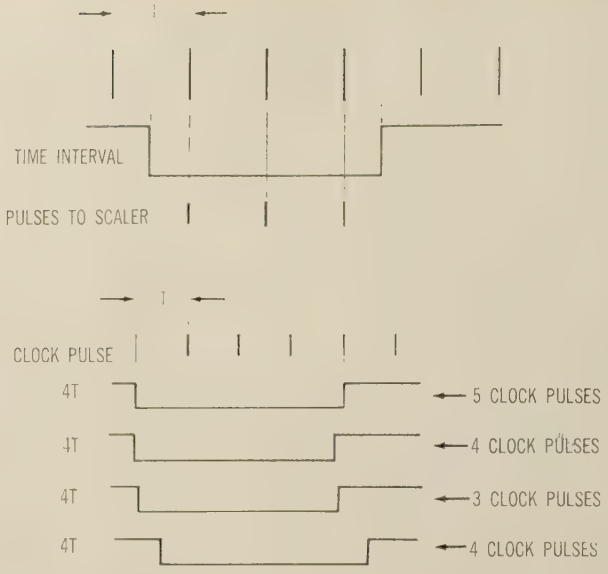

FIGURE 2: Clock pulse relationships in the light foot quantizer.

v_1 initial velocity for t. If both v_2 and v_1 are known between the same fractional limits $\pm m$, $v_2 - v_1$ will have a reduced accuracy as shown by the variation $\pm m(v_2 - v_1)/(v_2 - v_1)$ in $\Delta(v_2 - v_1)/(v_2 - v_1)$. If $v_2 = nv_1$, the variation becomes $\pm m(n + 1)/(n - 1)$. For example, if $v_2 = 1\frac{1}{2}v_1$, then $v_2 - v_1$ has five times the error of either v_2 or v_1 taken separately.

A further element of error in

more on page 106

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Our inertial guidance systems utilize two-degrees-of-freedom gyros. If you would like to do advanced work with these and have had at least a year of engineering experience, please write Mr. C. T. Petrie, Manager, Research & Engineering Staff.

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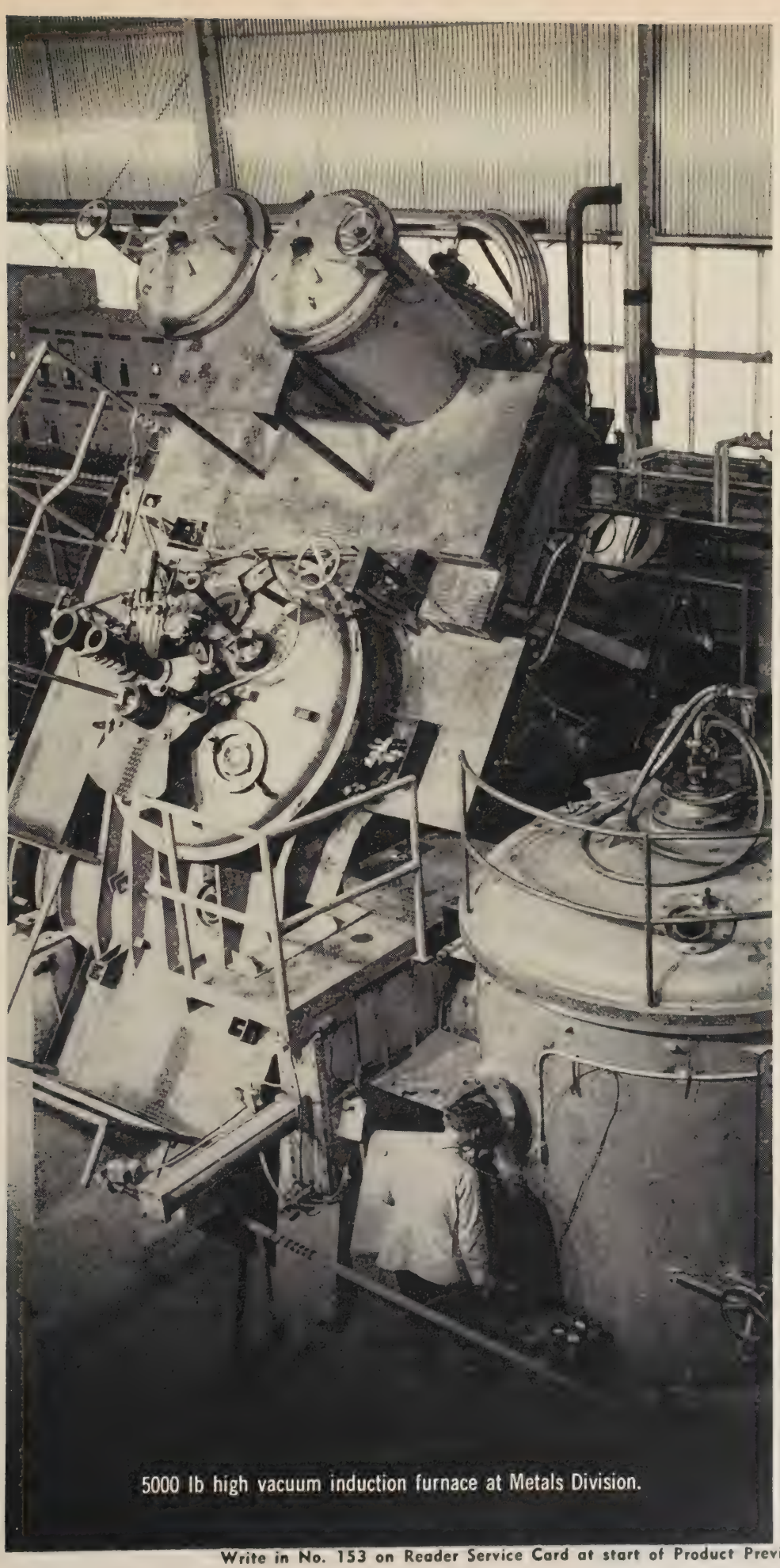

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K H

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Mark Intervals and Frequency vs Sled Speed

Sled Speed (fps)	Time between Marks (millisec)				Frequency of Passing (cps)			
	0.5 Ft	5 Ft	10 Ft	50 Ft	0.5 Ft	5 Ft	10 Ft	50 Ft
500	1	10	20	100	1000	100	50	10
1000	0.5	5	10	50	2000	200	100	20
2000	0.25	2.5	5	25	4000	400	200	40
3000	0.17	1.67	3.33	16.7	6000	600	300	60
4000	0.13	1.25	2.5	12.5	8000	800	400	80
5000	0.10	1.0	2.0	10	10,000	1000	500	100

the computation of acceleration is found by using the partial derivatives of *Equation 6*:

(8) $\Delta a/a = \Delta(v_s - v_1)/(v_s - v_1) + \Delta t/t$,

where Δa is the acceleration error.

As we can see, the accuracy to which acceleration can be measured is a very sensitive function of the accuracy to which t can be measured. The error effect is increased by a further order of magnitude in measuring changes of acceleration.

Conversion time is defined as the time required to complete one coding process. It can be no greater than the minimum interval required between successive samples. The space-time system requires continuous conversion.

The quantizing error is usually defined as "plus or minus the least significant digit" and, the system error as N seconds. Whichever of these two errors is greater is the one of prime importance.

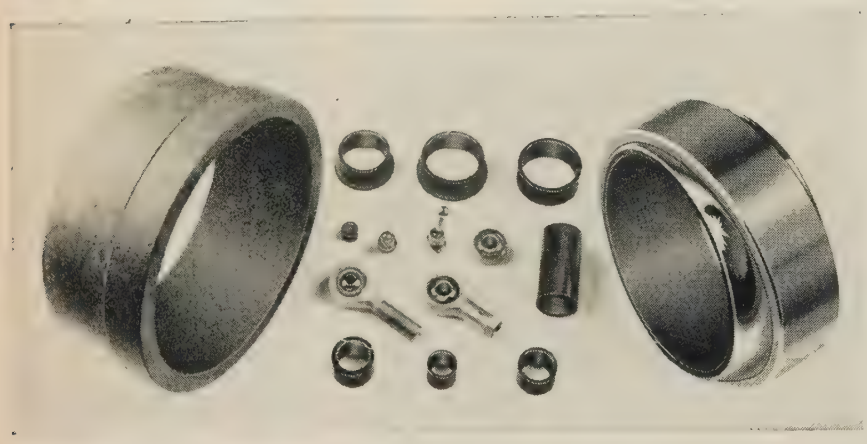
Figure 2 explains the significance of the quantizing error. It shows four time intervals either just larger or just smaller than four quantarouting three, four, or five clock pulses to a scaler. Discreteness and the asynchronous relationship between pulse train and interval give rise to boundary problems.

For example, let the quantum T equal period of the clock pulses, let t be interval to be quantized, and assume an asynchronous relationship between t and the clock pulses. Then if $2T < t < 3T$, two or three pulses may be counted; if $3T < t_1 < 4T$, three or four pulses may be counted; and so on.

Three pulses therefore could represent t or t_1, or an interval t_2 such that $2T < t_2 < 4T$, which in the scaler would register 011 plus or minus the weight (in this case $\rightarrow T$) of the least significant bit. Similarly, 100 may represent an interval t_3 such that $3T < t_3 < 5T$. An interval t such that $2T < t$ can never produce less than two pulses and must be considered as a part of the $2T < t < 3T$ quantum level.

These theoretical considerations are based on transition times $\pm\Delta t$ centered on NT and assumed to be zero. In any practical system, every attempt is made to reduce the "sampling aperture" to a duration that is small compared with the system resolution.

We must also remember that the scalers must propagate the carry before the conversion number is transferred to the main shift register, Any attempt to transfer the scaler on the fly assumes that the sampling aperture is, in the worst case, equal to the propagation time throughout the scaler. To make this duration short compared with 20 millimicrosec is extremely expensive in a long scaler. Write in No. 73 on Reader Service Card for more information.—End



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*E. I. Dupont's Tetrafluorethylene

U.S. Patent Nos. 2,804,886; 2,835,521; 2,885,248

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quality components engineered into the 'Y' Series produce an extremely flat voltage output from no-load to full-load.

Yet with all this space-weight compression the Y-Series retains the built-in rugged dependability which has made Chatham the foremost manufacturer of airborne power conversion equipment. Use of Chatham's own silicon diodes and sturdy cast aluminum heat sinks is further indication that Chatham designed with reliability in mind. The new axial flow design featuring fan cooling offers maximum mounting flexibility but demands the very minimum in space requirements with considerable cost savings. Fan operation is guaranteed for 7500 hours with a minimum expected life of 10,000 hours at 71°C ambient.

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MILITARY ELECTRONICS DIVISION — CHICAGO 24, ILLINOIS

URGENT PROBLEMS RELIABLY SOLVED

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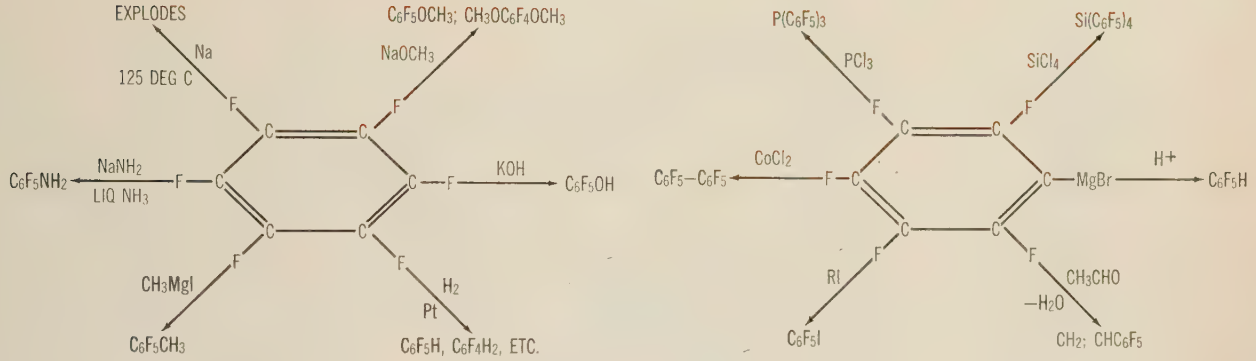

FIGURE 1: Hexafluorobenzene (left), starting material in synthesis of aromatic fluorocarbon polymers, and some compounds prepared from it. Right: Compounds synthesized from the Grignard reagent.

Fluorocarbon studies
lead to high temperature polymers

Research on aromatic fluorocarbons is expected to provide a new family of radiation-resistant high temperature plastics. NBS are studying many promising starting materials from which suitable polymers may be synthesized and several of which are described here.

TOTALLY fluorinated aromatic polymers promise to show greater resistance to high temperatures than any other polymeric material now available. A research program aimed at the synthesis of such polymers in the form of high temperature, radiation-resistant fluorocarbons is underway at the National Bureau of Standards, Washington 25, D. C.

As a first step, Dr. Leo A. Wall and others of NBS' Polymer Structure Lab are trying to produce aromatic fluorocarbon monomers, which can be used as starting materials and intermediates. Then they will attempt to convert these substances to suitable polymers.

Of great importance for this effort, states NBS, has been the development of methods for the synthesis of hexafluorobenzene (C_6F_6) in reasonable yields and quantities. C_6F_6 is an excellent starting material for the syntheses of some new monomers and polymeric compounds containing the perfluorophenyl or perfluorophenylene group (*Fig. 1*).

For the formation of polymer chains, derivatives of C_6F_6 with at least two reactive functional groups are needed. Researchers have also been thinking in terms of structures in which the perfluorophenyl group is pendant (branch- or sidewise) to the polymer chains. For these, monofunctional derivatives are also of great value, too. *Figure 3* shows

more on page 111

Where do you go from minus

Constant laboratory research and testing of rocket components, such as the valve above being subjected to simulated flight conditions, assure highly reliable performance from Thiokol rocket motors and engines

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typical examples of these two types of derivatives.

Only a few of the possible molecular structures can meet the required combination of high thermal stability and plasticity (or rubberiness). For example, says NBS, linear flexible molecular chains, with a large number of configurational possibilities and strong chemical bonds between all the atoms in the molecule, are needed. A structure approaching this ideal is polyperfluorophenylene ether (*Fig. 2*). Conversely, NBS notes, the polyperfluorodiphenylsiloxane polymer (*Fig. 2*) has a bulkier structure and can't be coiled without breaking its bonds.

The simplest and most direct way to synthesize appreciable amounts of C_6F_6, NBS reports, is to heat tribromofluoromethane. When this is done in a platinum furnace at 540 deg C and 50-265 psi pressure, yields exceed 55 per cent.

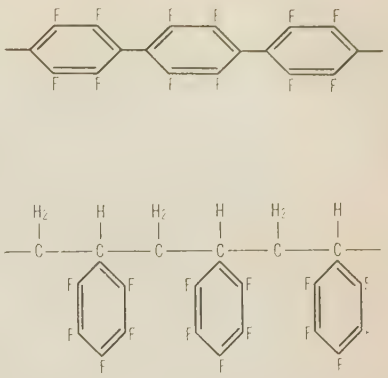


FIGURE 3: Two monofunctional derivatives are polyperfluorophenylene (top), which has a molecular weight of about 2000 and was prepared a few years ago from diiodotetrafluorobenzene, and the monomer of poly(1,2,3,4,5-pentafluorostyrene), which was recently produced from pentafluorobromobenzene.

Good intermediate compounds have been made

C_6F_6 has been used to derive a number of intermediate compounds from which to make high temperature polymers. In one case, pyridine was used as the solvent, since it promotes certain proton-seeking reactions, especially with oxygen-containing bases. The addition of methanolic NaOH to this solution produces pentafluoroanisole, that of solid KOH produces pentafluorophenol.

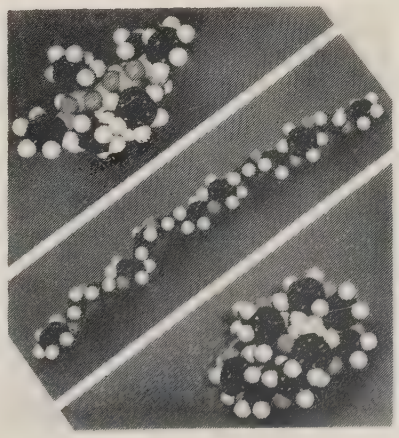
When alcoholic KOH is used as the base, pentafluorophenol, tetrafluorodihydroxybenzene, pentafluorophenetole, and a small amount of tetrafluorodiethoxybenzene are obtained. In liquid ammonia, pentafluoroaniline is produced from sodamide and benzene.

C_6F_6 can be readily reduced by hydrogen with a platinum catalyst, says NBS. The main products, pentafluorobenzene and tetrafluorobenzene, can be brominated to pentafluorobromobenzene and dibromotetrafluorobenzene or iodinated to the analagous iodides. Since these compounds contain readily displaced atoms (of bromine or iodine) in active sites, researchers state, they can be used to prepare aromatic fluorocarbons that can't be directly synthesized from C_6F_6.

Such reagents as methyl magnesium iodide can replace one or two of the fluorines in C_6F_6 to produce 1,2,3,4,5-pentafluorotoluene or one or more of the possible tetrafluoroxylenes. Since the hydrocarbon methyl group is easily oxidized to the carboxylic group, it offers a relatively easy route to dicarboxylic tetrafluorobenzene, another suitable intermediate. However, NBS stresses, attempts to prepare such derivatives as sodium pentafluorophenyl have led to vigorous explosions.

more on page 113

FIGURE 2: Polyperfluorophenylene ether (bottom) has a structure (shown extended and coiled) that is near-ideal for materials with high thermal stability and plasticity. Top: The bulky structure of polyperfluorodiphenylsiloxane is poorly suited to high thermal stability requirements.



320°F?

"Malfunction" is the most feared word a rocket scientist can hear. One of its most critical sources is *temperature*. Ranging from hundreds below zero to thousands above, temperature extremes can play havoc with milli-second performance specifications of complex valves and pumping systems.

In picture left, liquid nitrogen flowing through a turbo pump valve of a type used on the powerplant for the Air Force's X-15 drops the temperature within the valve to minus 320°F. This is slightly cooler than in actual operation, when the valve will pump highly combustible liquid oxygen (minus 297°F) and ammonia.

Laboratory tests are an essential part of the continuing research program in new materials, new design and new fuels, carried on by THIOKOL's rocket builders. In close support are the scientists of THIOKOL's Chemical Division, who continually seek new properties for their liquid polymers to meet increasing performance demands.

It is through such scientific team effort that THIOKOL has been able to design and build liquid and solid rocket propulsion systems having a remarkable record for flawless functioning.

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Propellant Analysis; Propellant Formulation; Organic and Inorganic Polymers; Fluorine and Metal Hydrides Synthesis; High Vacuum Techniques; Fast Reaction Kinetics; Shock Wave Phenomena; Combustion Processes.

For engineers, there are scores of exciting career opportunities in the areas of servo system and electro mechanical design, in instrumentation and many other phases of advanced propulsion research.

THIOKOL plants are located in areas that are good places to live—Bristol, Pennsylvania; Elkton, Maryland; Huntsville, Alabama; Marshall, Texas; Denville, New Jersey; Trenton, New Jersey; Brigham City, Utah; Moss Point, Miss. For further information contact: Personnel Director at any plant address above.

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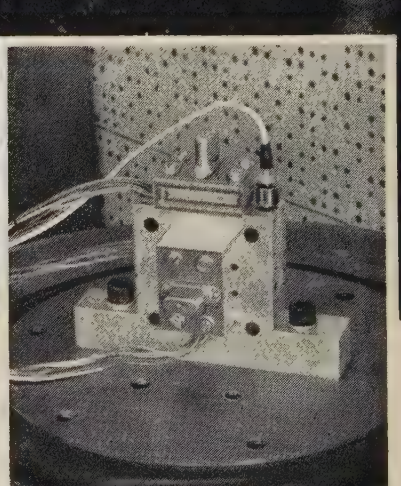

To the moon and back without leaving our lab

Rapid acceleration, vibration, violent shock, extreme temperatures—these are the environmental conditions found on a trip to the moon . . . and in General Electric's relay-testing laboratory as well. Here, exhaustive tests—simulating operating and atmospheric conditions—are conducted to continually verify the reliability of G-E sealed relays.

Even in standard production testing, General Electric goes well beyond requirements to assure reliability. Each lot of G-E relays is subjected to 27 tests and measurements before being released for shipment. For example, every relay built is subjected to a 15-cycle dynamic contact-resistance check—the prime indicator of cleanliness.

For one demanding application, General Electric and the customer scheduled 109 tests for each unit. A 5% lot sample was subjected to destructive tests including monitored six-hour vibration and load-life tests. A single relay failure meant rejection of the entire lot. During this contract, 23 consecutive lots (over 4000 relays) were processed without a lot-sample failure!

But testing is only part of G.E.'s reliability story. Design leadership (such as produced the Unimite, the world's smallest 1-amp relay) and advanced manufacturing techniques (includin new inert-arc welding to eliminate co tact-contaminating solder and flux) co sistently produce superior relays.

Obviously, all relays don't require th same testing—but whatever your nee —General Electric has the know-ho and facilities to meet them. See yo G-E Sales Engineer, or mail the coupo at right. General Electric Co., Specialt Control Dept., Waynesboro, Va.

Progress Is Our Most Important Product

GENERAL ELECTRI

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High energy irradiation of C_6F_6 produces mainly larger molecules similar in nature and quantity to those of irradiated benzene. Aromatic fluorocarbons, it appears, have the same high radiation resistance as aromatic hydrocarbons. At high temperatures, such fluorocarbons as polyperfluorostyrene may even have better radiation resistance than the aromatic hydrocarbons.

With pentafluorophenylmagnesium bromide it eventually will be possible to synthesize many complex aromatic fluorocarbons, says NBS. Pentafluorobromobenzene, obtained as a byproduct in preparing C_6F_6 by pyrolysis, is easily converted to a Grignard reagent that reacts with acetaldehyde to form pentafluorophenyl-α-ethanol. This alcohol can be dehydrated at 350 deg C by alumina pellets to 1,2,3,-4,5-pentafluorostyrene.

NBS is also working on the preparation of perfluorostyrene. Polymers of this compound are expected to have good radiation resistance. So far, coupling reactions involving Grignard reagents have proved unsatisfactory; reactions with the pentafluorophenyl Grignard and tetrafluoroethylene are still being explored.

Aromatic amidines should work out well

A good synthesis of perfluorodiphenyl was obtained by the Ullman condensation of pentafluorobromobenzene in a sealed tube at 250 deg C. With silicon tetrachloride and phosphorous trichloride, the Grignard has been used to produce tetrakis - (pentafluorophenyl) - silane and tris-(pentafluorophenyl)-phosphine.

Aliphatic fluorinated compounds, like the perfluoroalkyl nitriles and dinitriles, react with ammonia to form perfluoroalkylaminides or diaminides, and these condense to form polymers. In an analagous reaction with aromatic substances, pentafluorobenzonitrile (recently synthesized at NBS) and perfluorophthalydinitrile would form, respectively, pentafluorobenzamidine and perfluorophthaly-diamidine.

Since the aliphatic polymeric amidines are bonded through the triazine structure, say researchers, corresponding structures resulting from the aromatic amidines would have added stabilizing resonance energy. This energy would give them greatly improved thermal stability. The material would also have excellent rubber like properties over a wide temperature range, since it could exist in so many structural configurations. The combination of aromatic and aliphatic perfluoroamidine may produce copolymers with other improved properties.

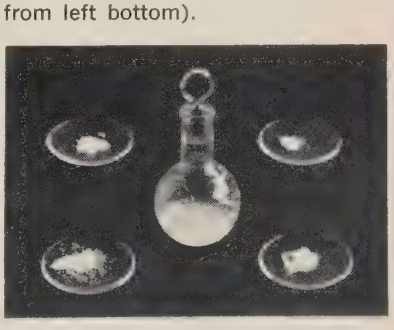
Silver salt heated for several hours

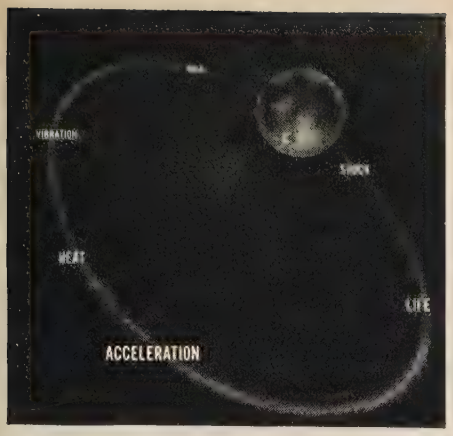
Sodium and silver pentafluorophenolates were prepared from pentafluorophenol. When the sodium derivative was thermally decomposed in a vacuum, the main products were an alkali-insoluble solid and a brown, tacky gum. When pure, the white solid melted between 163 and 165 deg C. It's believed this is the ortho dimer of pentafluorophenolate. The gum is believed to be a low-molecular-weight polyether derivative. NBS is trying to increase the molecular weight of this polymer. Efforts to prepare the perfluorodiphenyl ether from sodium pentafluoroether and C_6F_6 have remained unsuccessful.

Attempts to pyrolize the silver salt in a sealed tube at 200 deg C resulted in an explosive reaction. However, after a trace of iodine had been added, the same compound could be heated for several hours without detonation. The silver salts decompose photochemically and may react to form polymers unobtainable with the sodium derivatives.—**IS**

References—Y. Desirant, *Bul. Acad. Belg. Classe Sci.* 5/41, ('55). M. Heuman, E. Peters, W. J. Pummer & L. A. Wall, "Hexafluorobenzene from the Pyrolysis of Tribromofluoromethane"; *J. Am. Chem. Soc.* 79 ('57). J. A. Godsell, M. Stacev & J. C. Tatlow, *Nature*, 178 ('56). W. J. Pummer & L. A. Wall, "Reactions of Hexafluorobenzene;" *Science*, 127 ('58). E. J. Forbes, R. D. Richardson & J. C. Tatlow, *Chem. & Ind.*, 630 ('58). William Rielly & H. C. Brown, *J. Am. Chem. Soc.*, 78 ('56).

FIVE aromatic fluorocarbons synthesized at NBS: pentafluorophenol (center) and diiodofluorotetrabenzene, tetrakis - pentafluorophenylsilane, perfluorodiphenyl, and pentafluorobenzoic acid (counterclockwise from left bottom).





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UNIMITE: The world's smallest 1-amp sealed relay; single-pole type. Isolated contact chamber, high speed 1.5 millisecond operation.

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general characteristics

Maximum rated flow	valve pressure drop 1000 psi	3000 psi
Series 31	4 gpm	7 gpm
Series 32	8 gpm	14 gpm
Operating supply pressure	50 psi to 4000 psi	
Electrical signal power	40 milliwatts minimum	
Temperature range (fluid and ambient)	—65°F to 350°F standard, to 450°F or 600°F on special order	
Resolution	<½ %	
Hysteresis	<3%	
Null shift		
temperature —65°F to 450°F	<4%	
acceleration to 50g	<5%	
supply pressure 80% to 100%	<2%	
quiescent current 50% to 200% rated current	<2%	
back pressure 0% to 20% of supply	<2%	
Weight (approximate)	0.75 pounds	

series 31 and 32

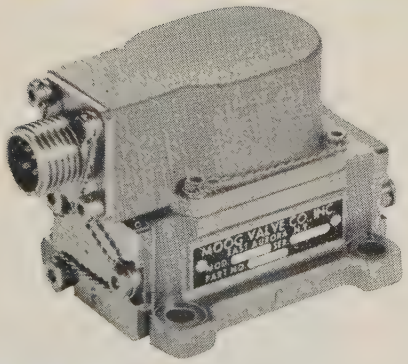
flow control

servovalves

with mechanical feedback

from

MOOG



Series 31 and 32 servovalves are miniaturized two-stage flow-control valves which utilize internal mechanical feedback. Features of the new design include high performance, simplification and compactness, together with a wide temperature capability. Specific valve characteristics can be achieved other than the ones listed above.

Write for catalog 310 and individual model data sheets that illustrate typical performance variations.

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Reversed lever causes gear downlock failure

TWO MAJOR accidents occurred when jet fighter landed with nose gears partly retracted and the main gears down. **Flight Safety Foundation, Inc., 468 4th Ave., New York 16, N. Y.,** reports. Cockpit indicators showed all landing gear units down and locked.

The landing gear downlock and door sequence switch, common to both nose and main landing gear warning actuating systems, failed to operate correctly. As a result, the cockpit indicator showed "safe" even though the nose gear was in an unsafe position.

A lever in the downlock and door sequence linkage mechanism inadvertently had been installed backwards. This mistake reduced the travel of the actuating mechanisms, and the downlock failed to operate. No provision had been made in the design of the lever to forestall operation of Murphy's Law: If a part can be installed incorrectly, someone will install it that way.

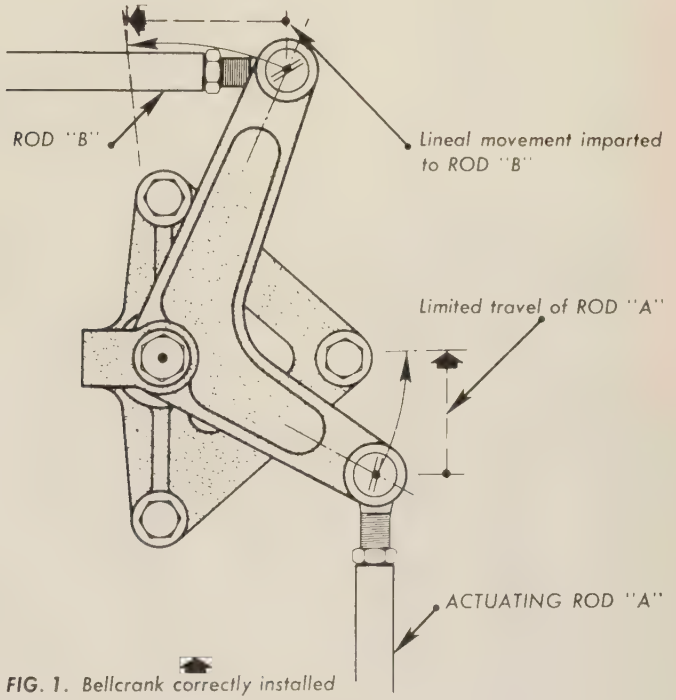

FIG. 1. Bellcrank correctly installed

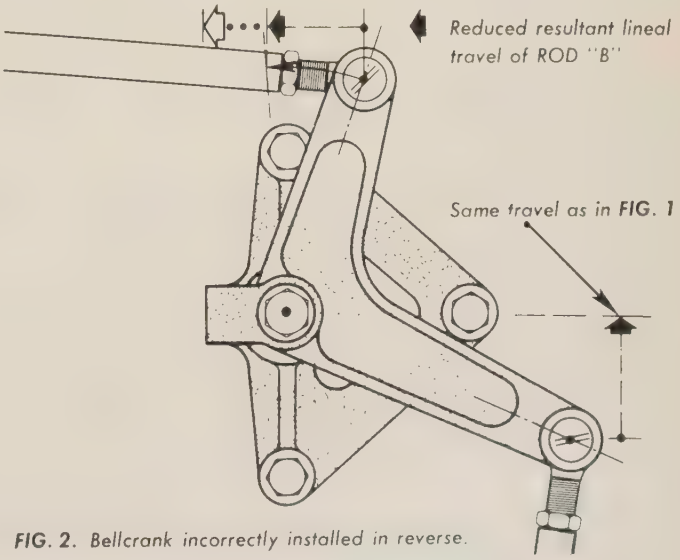

FIG. 2. Bellcrank incorrectly installed in reverse.

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Expanded facilities of Ryan Electronics at San Diego and Torrance in Southern California provide the optimum for working, living, educating your children and pursuing your own advanced studies. For immediate action, phone George Gerner, collect, **BRowning 7-6450,** San Diego, or send your resume to 5650 Kearny Mesa Road, San Diego, California.

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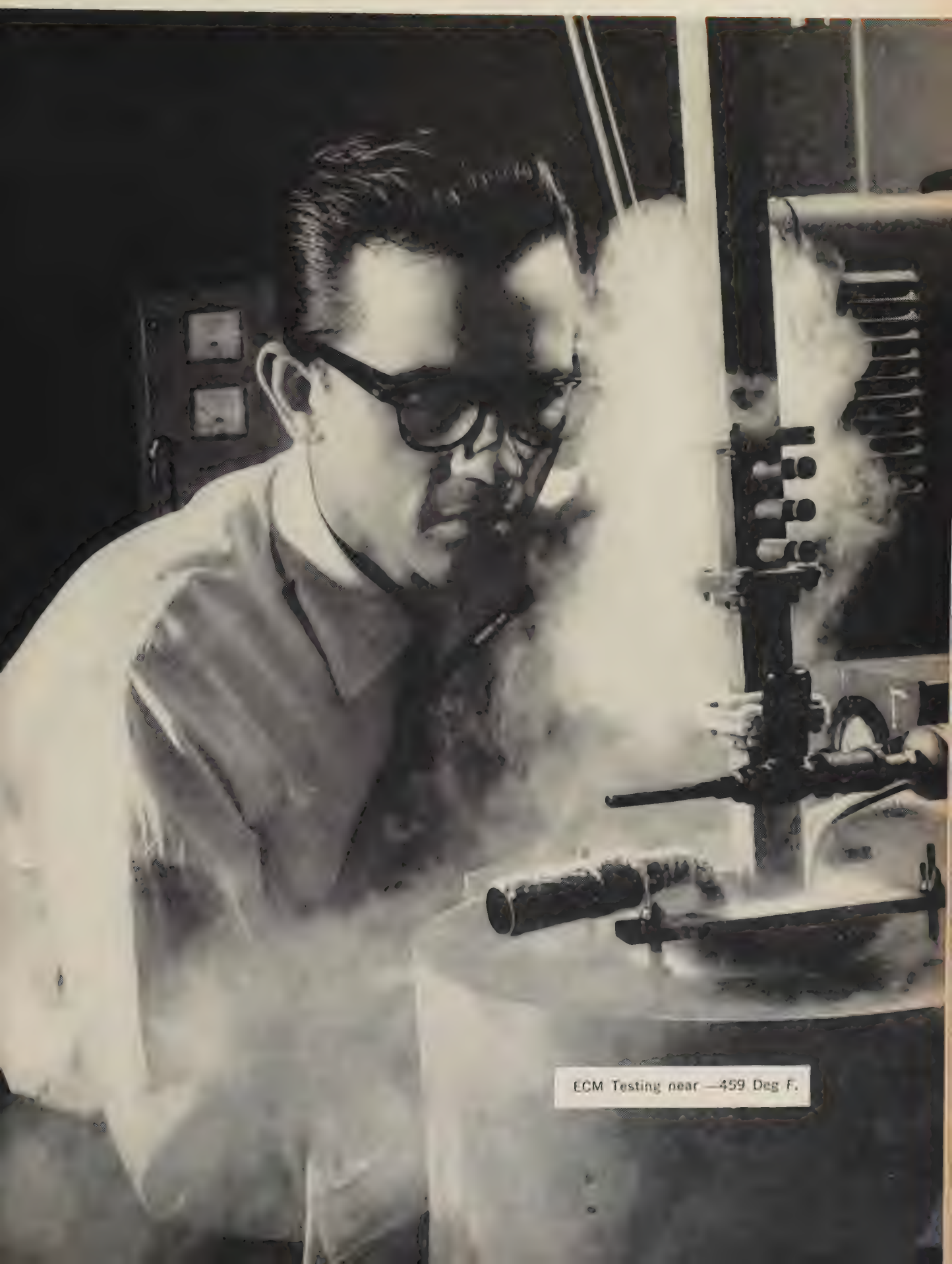
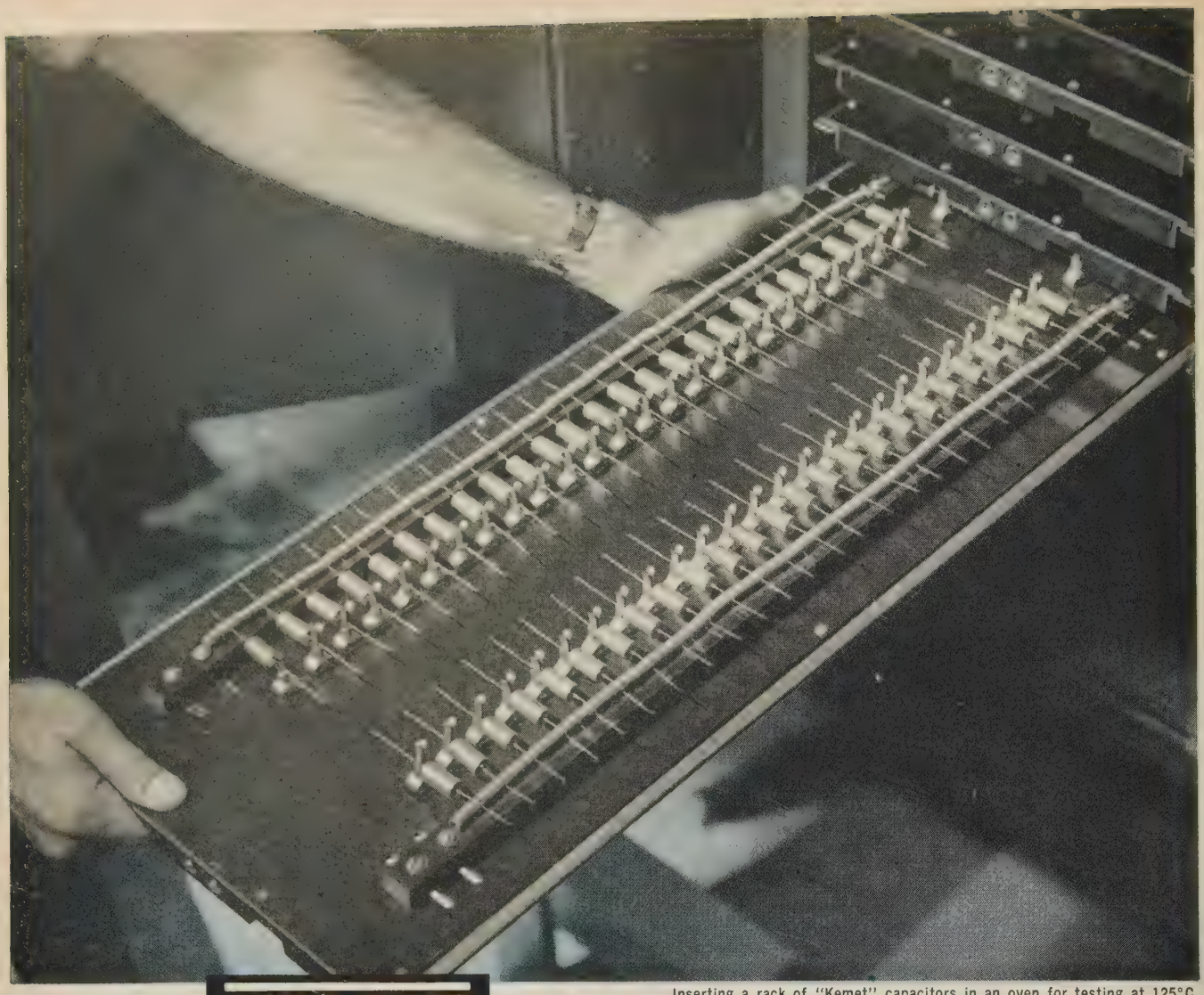
space aero Electronics



ECM Testing near —459 Deg F.



Inserting a rack of "Kemet" capacitors in an oven for testing at 125°C.

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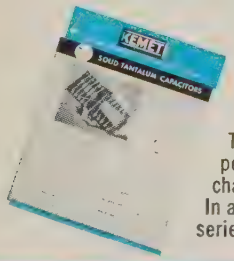
There is no one simple test to assure product quality in the manufacture of solid tantalum capacitors. Only a series of rigid tests can achieve this goal. At Kemet Company this program starts with 100% life testing.

Every capacitor shipped has passed a 250 to 300 hour life test at its rated voltage in a 125°C. oven. This test includes leakage, capacitance and dissipation measurements. From each test batch, two statistical samples are subjected to additional testing. One group is life tested for 1000 hours; other groups are slated for environmental tests.

Kemet Company has always conducted life tests with very low series resistance...no more than 100 ohms. In compliance with Air Force Specification MIL-C-26655, tests are now conducted without resistors.



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This six-page folder provides performance curves, operating characteristics and specifications. In addition, it offers a decade series of capacitance values.

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aerospace electronics intelligence

Electronics peak is reached in recon aircraft

THE STORY of electronic reconnaissance, if it ever is told, will have all the elements of a science-fiction thriller with plenty of cloak-and-dagger work. One of the major "cold war" tasks of our air forces today is to patrol the borders of iron curtain countries and sample and record electromagnetic radiations that emanate from the other side. Our side is looking for transmitter locations, operating frequencies, modulation schemes, rapid-tuning capabilities, duty cycles, power outputs, bandwidths, radiation patterns of radars and similar parameters for radio communications and navigation aids. We also want to know all we can find out about the Reds' active jamming capabilities.

The aircraft doing electronic recon work appear to be as highly electronified as anything flying today. They are believed to carry a variety of highly specialized equipment that often costs more than the airplanes themselves. Some of these planes are modified versions of our fastest fighter and tactical bombers.

The data obtained on these flights is carefully studied and processed. Much of it is used to guide ECM and CCM equipment and systems designers and tactical planners.

RECON PILOTS and crews probably have one of the most dangerous "peacetime" assignments. Borders are hard to observe, even at high altitudes and under VFR conditions, when there's a cloud cover, they are almost impossible to follow. Also the temptation must be great for the pilot to get closer to the barely intelligible sources of radiations deeper inside the Red empire. To date, our air forces are believed to have lost some two dozen planes on electronic surveillance missions.

Not only planes are being used for recon work. Ground, surface ship and some submarine stations reportedly are also playing important roles. Conceivably, electronic observer satellites might some day be used to get information from the impenetrable inner regions of the Red countries.

F-105D flights to test Autonetics' monopulse radar

MONOPULSE RADAR made by Autonetics is going through flight evaluation in Republic's supersonic, all-weather F-105D Thunderchief. Autonetics calls it "the nation's first, all-mode, multi-purpose production radar for fighter bomber aircraft." Operational modes are air-to-air search and autotracking, air-to-air ranging, air-to-air blind acquisition and attack, air-to-air visual acquisition and attack, and air-to-ground ranging. The radar makes all-weather low-level penetration possible, claims Autonetics.

FPS-24 FREQUENCY DIVERSITY radar, built by GE Heavy Military Electronics, will shortly go into service testing at Enfaula, Ala. It will become part of the Sage net.

Two-megacycle band proposed for space applications

SPECTRUM CHANGE proposed by the Federal Communications Commission would set aside the 135-136 mc for earth-space and space services. This segment is now allocated for government use. FCC also proposed to assign 126.825-128.825 and 132-135 mc for air traffic control. The former two megacycles are now used in the U.S. as airline company frequencies, the latter two are part of the government band.

•

ESAKI DIODE is being studied by IBM for use as a computer component. The company has built an experimental germanium oscillator with a fundamental frequency of 3010 mc and another with a 4020-mc fundamental. No cavities were used in the unconventional design. Instead an RLC-equivalent lumped-parameter semiconductor circuit determines the frequency of oscillation.

According to IBM, it has achieved the highest frequencies of oscillation reported for the Esaki diode to date—and the high frequency limit of the oscillator design is still not known, says IBM.

MAGNETIC ROD STORAGE is being studied by National Cash Register under a contract from USAF's Cambridge (Mass.) Research Center. The

more on next page

Cover story — Testing of countermeasures components at Sperry Gyroscope. Unit is being subjected to near-absolute-zero (—459 deg F) conditions in a bath of liquid helium within a cryostat. At these temperatures, metals become superconductors of electricity.

project, says NCR, will provide background data for the eventual development of a general-purpose, solid-state airborne digital computer.

The rod development by NCR researchers is about 0.015 in. in diameter and is given a tiny magnetic coating by a special electrochemical process. Operated in a coincident-current mode, the rod has a switching speed of about 70 millimicrosec. Output voltage in operation across a 10-turn sense winding ranges from 200 to 500 mv. The rod can also be used as a multi-input logic switch. It gives satisfactory operation in the 2-5-mc range when used together with transistors, says NCR.

The advantage of rod-type computers is that they are less bulky than core types.

N-156F flight tests to use PCM telemetry and data handling

PCM TELEMETRY and data handling will be used in the flight testing of Northrop's N-156F. Radiation Inc. will design and build the PCM system.

The system's airborne components will be able to accept 96 inputs at a level of ±20 mv full scale. Analog-to-digital conversion will occur at controllable rate increments ranging through 3.2, 6.4, 12.8, and 25.6 kc.

The ground equipment will include data editing and tape-to-tape conversion units. The latter will translate data for direct insertion into IBM 704 and 709 computers.

•

IMPROVED VERSION of Sperry's Race (*R*apid *a*utomatic *c*heckout *e*quipment) will be built for "very advanced airborne electronic equipment" under development by an eight-company team headed by Airborne Instruments Laboratory.

Firestreak said to be over twice as good as Sidewinder

RELIABLE BRITISH sources claim the lethality of de Havilland's Firestreak is 80 per cent but that of Navy's Sidewinder is only 30 per cent. Both missiles use infrared homing; the Firestreak's design is about four years "younger" than that of the present Sidewinder.

According to de Havilland, the present Sidewinder can't compete with the Firestreak against a maneuvering target.

IN THE FIRESTREAK, de Havilland uses a gimbal-mounted, stabilized IR telescope with a wide field or view. To determine optimum delay times, an IR proximity fuze is used together with a fuze computer.

DH reportedly is working on a successor to the Firestreak, the Redtop, whose homer makes use of the most recent developments in the infrared art.

•

LONG BASE LINE *RADAR* (Lobar) for missile detection will be tested at ITT Labs, Nutley, N. J. Originally the tests were scheduled for the Caribbean area.

ELECTRONIC SYSTEM EVALUATOR developed by GE's Defense System Dept. will let design engineers predict whether a system that hasn't gone into production yet will operate at top efficiency. Basically an analog computer, the Geese (*GE electronic system evaluator*) system will simulate all types of radar and communications systems. It will also measure a system's vulnerability to countermeasures and the danger of interference from "friendly" electronic systems.

Geese, says GE, can "shorten conventional development cycles by as much as 25 per cent." The company also claims its evaluator will make it possible to develop better electronic systems.

Sperry designs highly integrated navigation system

INTEGRATED navigation and instrument system developed by Sperry for Army planes is built around a lightweight Doppler radar, a gyrosyn compass, a vertical gyro, and an automatic navigation computer with a memory. The system's sensors are not new types, but the Sperry designers appear to have done a thoroughgoing job of integration. Into a 120-lb system, Sperry has built a self-contained navigator that includes a nine-inch-square pictorial map-type display of aircraft position and progress, absolute (radar) altitude, and some distinctly new flight instruments. These include pictorial compass deviation indicator that shows the pilot how to fly to make good his course and a horizon flight director that displays aircraft attitude and lets a pilot follow any desired flight path by centering two cross pointers on the face of the indicator. An ETA indicator is also planned for the system.

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MICROCIRCUIT technique worked out by International Resistance Co. is the latest publicly announced development in the fast-growing "integrated electronics" field. IRC's microcircuits use

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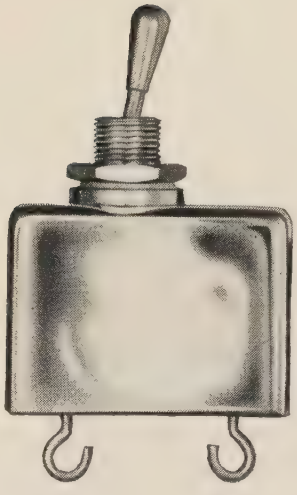
ACTUAL SIZE



This is the actual size of Heinemann's new sub-miniature circuit breaker, the SM3. Hermetic seal and all, it weighs no more than a bantam 2.1 ounces. It is magnetically actuated, therefore does not require de-rating for high ambient temperatures. In fact, under extensive environment-testing, the breaker has demonstrated excellent all-around operational stability. It will function properly on the tundra or in the tropics, will withstand the onslaughts of salt-sea atmosphere, sand, dust and high humidity. The SM3 is available to your specifications in any integral or fractional current rating from 0.050 to 10 amperes, at 110V, either 60 or 400 cycles AC, or 50V DC. And you have a choice of either fast or slow time delay, so that overload response can be matched closely to the operating characteristics of the protected equipment. If you have need of a rugged, compact circuit breaker "packaged" to go anywhere, you'd do well to give the SM3 some serious consideration. The facts and figures are presented for your review in Bulletin 3502. Write for a copy today.

HEINEMANN ELECTRIC COMPANY, 170 PLUM ST. TRENTON 2, N.J.

Write in No. 85 on Reader Service Card at start of Product Preview Section

thin films of component material deposited on glass substrates "smaller than a postage stamp." The new technique was developed to help subminiaturize the "third-generation" inertial guidance computer Arma is designing for the Atlas ICBM.

IRC is the first major electronic component manufacturer to announce an "integrated circuit". Look for similar announcements soon from IRC's competitors. (All the major component manufacturers are working on some phase of circuit integration.)

SOLAR CELLS for Explorer VII provide five watts. Half of this power goes to the satellite's instrumentation and radios and half to charge the storage batteries. The cells are grouped in six equal-power clusters, any of which can supply the full five watts. The clusters are spaced so that at any time when the satellite is not in the earth's shadow, at least one of them is in full sunlight.

TWENTY-POUND radar altimeter being produced by Télégraphie sans Fil in France uses transistors in all stages, except for a triode transmitter final. It is an FM type and operates on 1600 mc., size is 0.2 cu ft; power drain, less than five amperes. The unit's scale is essentially logarithmic, being graduated from zero to 10,000 ft.

Self-adaptive flight control studied for spacecraft

UNDER WADC CONTRACT, Minneapolis-Honeywell will study the design of self-adaptive flight control systems for advanced space vehicles. The hardware developed from this study will be flight-tested on a North American X-15.

The big problem, M-H engineers point out, lies "in controlling the transition from the use of aerodynamic surfaces in the atmosphere to pure reaction control of the vehicle in space." M-H's first job will be to define the flight control requirements for space vehicles, including an operational systems analysis and human factors studies. For the building of the flight-test prototype, NAA will make available its X-15 control system simulator to help the program along.

•

ELECTRONIC space cameras that can take a continuous strip record of the earth's weather or the moon's surface and broadcast it in the form of TV signals to ground stations is being developed at RCA's Astro-Electronic Products Div. They are compact units whose basic elements are a special electrostatic tape and an electron gun of the type used on conventional TV.

According to RCA scientists, a lab model has been produced in which the elements are built into a glass vacuum tube shaped roughly like a mushroom. The "stem" is a TV pickup tube containing the electron gun. The "head" holds a roll of electrostatic tape mounted in an automatic wind-rewind assembly that alternatively winds and rewinds during exposure and readout.

Transmitter would send camera data from the spacecraft

MOUNTED IN A SPACECRAFT, the camera would use a conventional photo lens system and a low-power transmitter for broadcasting data to earth. The tape consists of thin layers of conducting, photo-sensitive, and insulating materials on a transparent base.

Before each exposure, the part of tape that is unrolled before the lens gets a uniform electric charge through "flooding" from the electron gun at the rear of the tube. After exposure, the charge is driven from the tape in accordance with the intensity of light in the scene viewed through the lens. The result is an electric charge pattern on the tape that corresponds to the light pattern of the image.

The tape can then be moved ahead automatically for the next exposure, storing the image until it is to be read out. In lab tests, images have been stored in this manner for up to two weeks without noticeable deterioration, says RCA.

•

THIN FILM COATING developed at Bausch & Lomb reportedly provides a way of controlling the temperature of satellite electronic systems. Covering the satellite's solar batteries, the coating reradiates heat into space. Engineers in B&L's Vacuum Coating Dept. point out that the sun's intense heat not only reduces the efficiency of electronic gear for radio transmission in outer space but may even melt the solder fittings that hold the batteries together.

The new coating, made up of films of magnesium fluoride and silicon monoxide, is less than 2.5 microns thick. It "cools" the solar batteries by reradiating the long wavelength heat rays. At the same time, it lets the cells absorb the shorter radiation needed to produce electric energy. The coating could mean the difference between losing radio contact with a satellite after a few hours or

more on next page

SATELLITE RELAY

. . . for modern long-range communications

Pony Express riders began an American tradition for the reliable relay of important messages over long distances. Today, Bendix is proud of its role in extending this tradition to SAC communications through the active radio relay satellite program.

Under Project STEER, Bendix has prime responsibility for the entire communication system. STEER will use polar orbit satellites to relay commands and pilot messages between Air Force ground stations in the United States and SAC bombers ranging on global missions. The ideal vantage point of a satellite relay will permit utilization of line-of-sight advanced UHF techniques. The fading and interference problems inherent in the ionospheric transmissions of present HF long-range communications will be avoided.

Other space age projects at the Bendix Systems Division include magnetohydrodynamics, highly reliable radiation-resistant communication equipment, interpretation and prediction of infrared reconnaissance, new satellite stabilization techniques, and communication methods to penetrate the ionized shock layer surrounding hypersonic vehicles. Additional projects involve satellites for weather and ground infrared reconnaissance, and for radio navigation.

Opportunities are open to better engineers and scientists interested in participating in advanced space programs in an ideal scientific climate.

Bendix Systems Division
ANN ARBOR, MICHIGAN

Bendix AVIATION CORPORATION

Write in No. 86 on Reader Service Card at start of Product Preview Section

days and maintaining radio reception so long as the satellite remains in orbit, says B&L.

NEW WATER-COOLING arrangement designed by Raytheon engineers for such high-power microwave amplifier tubes as the amplitron now lets them get over 10 times more power out of tubes despite fixed size limits. The water coolant flows under high pressure and at high speed through channels with a small cross-section. They efficiently remove the heat due to the residual energy of spent electrons as electrons collide on the outer surfaces of the water-cooled vanes.

High performance microwave systems are within our reach now

THE EXTREMELY HIGH powers and high efficiencies required for the ultra-long-range Dew radars and such ambitious schemes as its proposal for the "Ramp" high altitude hovering platform with ground-based microwave transmission are now within grasp, Raytheon discloses.

Ramp's C-band microwave power is to be generated in a ground station by a battery of amplitrons and sent via converging beams from a 400-ft-square ground array to the sky platform. There it is to be converted into electrical energy. Without the "cool" amplitron, this design would not be practical, Raytheon engineers told SPACE/AERONAUTICS. They pointed out that the only efficient super-power generators (other than the amplitron) are in the low frequency range—and to focus LF energy into the small area of a sky platform would have required antenna arrays thousands of feet in diameter.

ACCORDING TO RAYTHEON, the main problems in designing the microwave-powered Ramp system—building the 12-phase MW transmitter and developing the hovering platform's engine and rotor—can be solved without a major breakthrough in the state of the art. The key element of the system is the amplitron. With 10 db, it doesn't have the gain of other high power amplifiers (the klystron has 40 db, for instance, but Raytheon overcomes this drawback by ganging amplitrons).

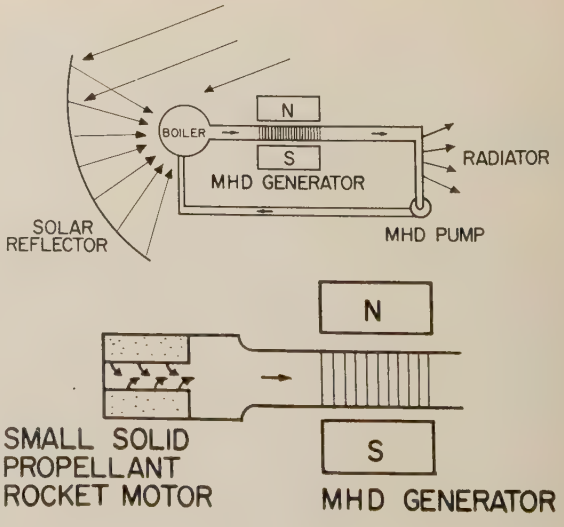
The efficiency of the Ramp system is broken down by its designers: propulsion system, 30 per cent; heat exchanger conversion, 95 per cent; airborne power receiving antenna, 65 per cent; atmospheric transmission, 95 per cent; radiation pattern design, 75 per cent; ground power transmission antenna, 65 per cent. The overall system efficiency (in terms of the ratio of generated MW power to rotor power) is 8.6.

MHD power proposed for spacecraft generator with long endurance

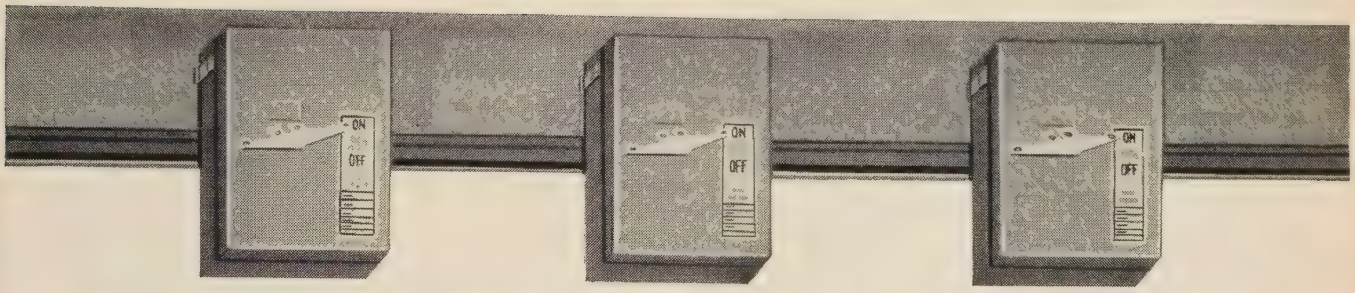
MAGNETOHYDRODYNAMIC power generation may offer a way out of the difficult problem of providing a reliable, reasonably light high power generator for space craft electronics that could operate over long periods. Scientists at GE's Aerosciences Lab have succeeded in converting the energy of a high temperature air plasma directly into electrical energy with an MHD generator. They were able to get about one kilowatt for a period of five seconds. In principle, says GE, the MHD generator can operate indefinitely.

MHD AND CONVENTIONAL power generation are similar in that both are based on the generation of voltage by the movement of a conductor through a magnetic field. In the MHD device, the conductor is a very hot ionized gas, while in the conventional generator it's usually a copper wire.

In GE's generator, the conducting gas flows past a magnetic field, cutting lines of force and producing a voltage in the gas (see *Diagram*). Power is extracted from the flow by electrodes. The process, says GE, can follow either an open cycle (*bottom*), with the gas exhausted after use, or a closed cycle (*top*), with the gas continually recirculated. Solar energy and the rocket exhaust, respectively, could power these systems.



NEW IDEA!



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New Westinghouse high-frequency bus duct (180 to 20,000 cycles) is the first efficient, economical method for high-frequency power distribution. Here is the final answer to high-frequency power problems. You'll never again settle for the inefficiencies of conventional systems in this application or put up with the expense, clutter and installation difficulties of multiple-run cable and conduit schemes. Or buy individual, on-the-site, high-frequency power generators for every testing station, high-speed machine, launching pads or on-line aircraft.

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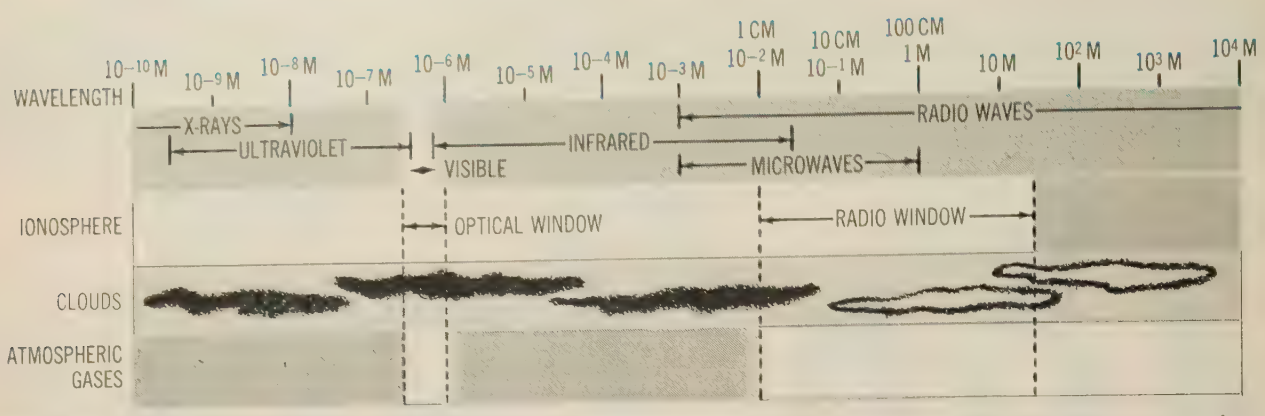

WINDOWS IN SPACE are just about restricted to the visible-light region and the 0.01-30-m portion of the radio spectrum. Operating frequencies for space communications must fall between 100 and 10,000 mc.

Designing for space communications

To communications engineers, space flight poses a tremendous challenge—without reliable communications, we won't get very far in space research. The first practical results of their efforts most likely will be the extension of earth-to-earth communications by moon or satellite bounce.

by Joseph Vogelman, Director, Research & Development, Dynamic Electronics Div., Capehart Corp.*

SPACE COMMUNICATIONS may take two forms: (1) communication *to* the earth *via* spacecraft of celestial bodies and (2) communication *with* vehicles or bodies in space.

In both cases, the frequencies below 100 mc should be avoided. All the disturbances that make ionospheric and meteoric scatter propagation possible also make it undesirable to use the region below 100 mc for signals that must pass through the boundary between atmosphere and space.

The upper frequency boundary for space communications is set by atmospheric absorption and lies around 10,000 mc. The operating frequency then must be chosen within the 100-10,000-mc part of the radio spectrum. This choice involves too many of the usual tradeoffs among power output, antenna size, bandwidth, noise figure, etc. and additional ones caused by such effects as Doppler shift, multipath, and Faraday rotation.

One of the most obvious celestial bodies for use as a signal reflector is the moon. Measurements and calculations show that it can be considered a semi-smooth reflector. It has a permittivity of 9.5×10^{-12} f/m and a mean conductivity of 4.8×10^{-4} mho/m—characteristics roughly equivalent to those of dry sand.

From the earth, the moon subtends an arc of something less than ½ deg. This small arc naturally calls for the highest possible frequency if all the radiated

* Dynamic Electronics Div., Capehart Corp., Richmond Hill, N.Y.

energy is to be focused on the moon's surface with an antenna of reasonable size. The highest frequency also requires the least correction for Faraday rotation. For example, the Faraday correction is a negligible one at degree 10 kmc but increases to as much as 90 deg at 100 mc. Of course, if circular instead of linear polarization is used, no correction is needed, but the designer has to take a drop of several decibels in gain.

To some extent, unfortunately, the advantages of the higher frequencies remain theoretical: The present state of the art in electromagnetic power generators limits us to at most three kmc for high transmitter powers.

In the case of any space vehicle or body that is in motion relative to the earth, the Doppler-shift problem rears its ugly head. Caused by the moon-earth relative motion the frequency shift of the earth-moon-earth communications path amounts to 0.1987 cps/mc at the North Pole and 1.362 cps/mc at New York City; it reaches a maximum of 1.5 cps/mc at the equator.

To correct for the shift, the designer can put the burden on the receiver or on the transmitter or divide it between the two. In the first case, the transmitter emits on its assigned frequency and the moon bounce is picked up by receivers located at different, precisely known points on the earth. The received frequencies can then be used to compute the Doppler shift due to the relative motions of both receiver and transmitter.

In the second, and apparently more advantageous, solution, the Doppler shift is computed at the transmitter and corrected so that all frequencies are correct at the moon's surface. It is now easier, of course, for one transmitter to communicate with a large number of receivers. The receiving stations must each have a computer to track the moon anyway, and these computers could also be used to correct for Doppler drift.

For propagation purposes, the earth is in the near (Fresnel) zone of the moon—the earth-moon distance lis less than the square of the diameter of the moon divided by the wavelength (d^2/λ) for all practical frequencies in the radio window. This explains the ringing (multipath reflections) we get when we reflect signals from the moon. The near zone applies for all planets of our solar system, too, and obviously also for the sun.

Multipath raises some particularly difficult problems when the moon is used as a communications relay and largely influences the bandwidth of the communications channels. Even though the moon as a radio-reflective surface can be regarded as semi-smooth, it contains a number of "corner reflectors". There are about 10 areas of strong return on the moon, all falling within one-third of the moon's radius. Each of these areas is a source of multipath.

Multipath produces pulse elongations of 600 usec. If you send a sufficiently narrow pulse, the return signals show a normal return from the smooth surface plus stronger pulses, staggered in time, that are the returns from the highly reflective areas.

The moon's libration, or swaying motion on its own axis, is another source of multipath—to an extent that is not precisely known so far.

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Space Communications Frequencies

Use	Frequency Band (mc)	Obstacles
Earth to space	100-10,000	Doppler shift, Faraday rotation, tracking stabilization
Space to space	<3	antenna size
	3-10,000	antenna size, power
	10^4-10^{10}	tracking & stabilization
On the moon	<3(ground wave)	antenna size, power
	3×10^{10} (line of sight)	very short range
On the planets	<3 (ground wave)	antenna size
	3-30 (reflected wave)	ionosphere (?)
	30-10,000	scatter (?), metors (?)
	>10,000	?

Space Communications—State of the Art

Tracking Antennas:	60 ft, 84 ft, 250 ft (Jodrell Banks)
Transmitters:	10 kw (100-300 mc), 2 kw (3000-10,000 mc)
Receivers:	Parametric amplifiers (at 290 deg C)—1 db
	Masers (at 4 deg C)—3 db
Power sources:	solar cells, thermoelectric batteries, nuclear reactors

Possible Space Communications System

FM	pulse to pulse
Frequency	10 kmc
Peak transmitter power	250 kw
Antenna diameter	60 ft
Antenna beamwidth	0.1 deg
Bandwidth	200 kc
Pulse length (ignoring multipath transmission)	5 usec
Approx. modulation loss	22 db

One interesting point is that the surface separations of the reflecting areas are in the order of 30 miles. Knowing the separation of the strong echo areas and assuming a pulsewidth of 300 microsec, we can estimate the coherent bandwidths for minimum multipaths as being somewhere between 1000 and 3000 cps.

A possible earth-moon-earth communications system could transmit FM pulse-to-pulse at 10 kmc. (In FM pulse-to-pulse every pulse is transmitted at a different RF frequency, so that multipaths can be ignored.) With a peak transmitter power of 250 kw and a 60-ft antenna (which produces a 0.01-deg beamwidth at 10 kmc), a bandwidth of 300 kc can be obtained. If it used five-microsecond pulses, the system would have a modulation loss of around 22 db. The same peak power, frequency, and antenna, could also be used for CW emission modulated either with standard single- or double-sideband AM at a bandwidth on the order of 2500 cps.

One of the most ticklish problems we can foresee for the earth-moon-earth link would be tracking. A computer would be needed to control both azimuth and elevation to 1/10 deg if the antenna is to be kept pointed at the exact center of the moon. Fortunately, we've been tracking the moon for thousands of years and its ephemeris is known to well within 1/10 deg.

Reflectors for passive satellites

Now let's turn to man-made satellites for both passive and active communications. First, the passive types. An obvious question concerns the shape of the reflector. Among the possibilities are:

- *a metal-coated sphere,* with which you can use the standard radar equations;
- *a fragmented spherical surface,* or only that part of the sphere that produces most of the return;
- *a Van Atta array,* which is an antenna made up of dipoles that reflect the signal back to its source but, for a wide beam, has very small gains on the return path;
- *a corner reflector,* which would have to be extremely small if the entire earth were to be encompassed by its beam;
- *a plane surface.*

The frequency range again is 100-10,000 mc, limited by ionospheric reflection-refraction and by atmospheric absorption. Of course, you want to put the maximum amount of energy on the satellite with the smallest possible antenna. You also must make your beam as fat as possible so that you can easily locate your target in space and at the same time make it as thin as possible for maximum antenna gain, so you'll end up with a beamwidth somewhere between these contradictory extremes.

What about Doppler shift? At 1000 miles altitude, for instance, a satellite produces a shift that varies from zero to 30 cps/mc. At 1000 mc, you might need as much as 30 kc correction—you're going to have to use 30 kc of bandwidth in addition to the bandwidth you need for receiving useful information.

At 22,400 miles altitude, you get a lucky break—there's the fortunate condition of no Doppler shift, for the satellite is rotating synchronously with the earth. The satellite is always in the same place, so you can make an antenna by simply digging a large hole in the ground and contouring it to the shape of a parabola.

The bandwidth of a passive satellite communications system is a function of the available power, Q of the antenna and of the operating frequency. At constant Q, the highest frequency gives the largest bandwidth. Of course, system noise, which goes up with bandwidth, is also a limiting factor.

A typical passive satellite system might have a transmission frequency of 2000 mc, a peak power of 60 kw, a receiver noise figure of six decibels, a signal-noise ratio of one decibel, and a ground antenna reflector of 60 ft diameter. For the orbiting reflector, either a 1000-ft sphere or an equivalent spherical section of 174 ft could be used. It would have a bandwidth of 552 cps. (With a sphere one nautical mile in diameter or an equivalent spherical section of 1043 ft, a bandwidth of 54 kc is possible. This roughly corresponds to 12

Active Satellite Relay		Performance of Synchronous Communications Satellite at 22,600 Miles*			
Low Level Storage & Readout:	recording media & storage capacity, random readout, selective calling readout	With 17-db-gain antenna in optimum orientation			
		Bandwidth (cps)	6210	24,840	53,900
		Satellite transmtter power (W)	3×10^{-3}	12×10^{-3}	27×10^{-3}
Low Level Repeater:	large number for world-wide coverage, limited bandwidth, universal controlled ground transmissions	Satellite gain (db)	52	58	61.5
		With isotropic antenna			
Synchronous Satellite Repeater:	limited bandwidth frequency division or time sharing	Satellite transmitter power (W)	0.114	0.456	1.026
		Satellite gain (db)	83.4	89.4	92.9

*With 60-kw ground transmitter and 60-ft parabola at two-kc frequency, six-decibel noise figure, and 10-db ground receiver S/N ratio.

voice channels on an ordinary multiplexed telephone circuit.)

At an altitude of 1000 miles it would take a satellite some 20 minutes to go from one horizon to the other. It wouldn't be at all easy to track—like the moon, it would have to be followed within 0.1 deg with an antenna that may be 60-250 ft in diameter and weigh 60-200 tons.

Doppler correction prediction to 100 cps in our typical system could be scheduled, assuming the system had good AFC. If suppressed carrier SSB were used, this correction would be just about good enough for intelligible speech.

For a spherical satellite, no stabilization would be needed—no harm would be done if it tumbled or rotated. A spherical-segment reflector, however, would be stabilized within two degrees. It could be orbited at the equator in synchronism with the earth's rotation, with the magnetic field lines parallel to the earth's surface controlling the orientation of the segment with respect to a radius drawn from the segment to the center of the earth.

For a Van Atta array, stability to within two degrees is likewise needed. It could be achieved by suspending the array from the center of a large, dumb-bell-shaped vehicle. This carrier would also work for the corner reflector, which must be precisely stabilized, too.

The stability requirements are highest for the plane-surface reflector, whose stability would have to be controlled to better than one degree. Such stabilization so far is unachievable.

Three types of active satellites

Among active communications satellites, there are three types: low-level storage and readout designs, low-level repeaters, and synchronous repeaters.

The low-level storage and readout satellite is a sort of orbiting post office. It has recording and storage media, and you send it a message with instructions on where to release it. It needs, of course, a random readout in order to receive and repeat messages for all over the country in a sequence that is not related to the path it traverses. It also needs a selective-calling readout, so that it can send messages to the right places on request from the ground.

The low-level repeater, stores nothing. It just repeats everything as fast as it comes in. You would need a large number of these satellites for worldwide coverage, or you would need extreme precision—to put them every 200 miles at 300 miles altitude evenly spaced all around the world and then have them pass by any given point at a uniform rate.

Statistical calculations show that we would need something like 4000 low-level repeaters at 330-1000 miles altitude for worldwide coverage. Since there's a limit to the amount of electronics you can put into these satellites, they are expected to have limited bandwidth. Finally, to avoid chaotic interference, you would need a universally controlled ground transmission system.

The synchronous repeaters also will have only a limited bandwidth capacity—like all our first-generation satellites, it probably will not be able to carry a large amount of equipment. Therefore it is very likely that they will be used then on a frequency- or time-shared basis. Incidentally, since a synchronous repeater stands still over one spot on the earth's surface, it would be suitable for the exclusive use of a limited number of

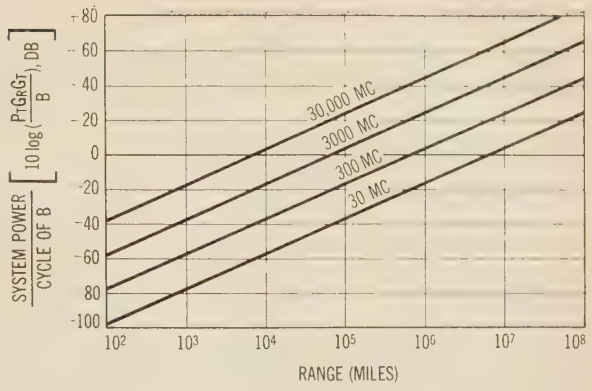

FIGURE 1: Transmission parameters for space communications. For example, with a transmission frequency of 3000 mc and a receiving system of one cycle bandwidth and zero decibels noise figure, 22 db of system transmission power (above one watt) is needed to cover a range of 10^6 miles. At 10 kc bandwidth and 10 db noise figure, 52 dbw is needed for the same range and frequency.

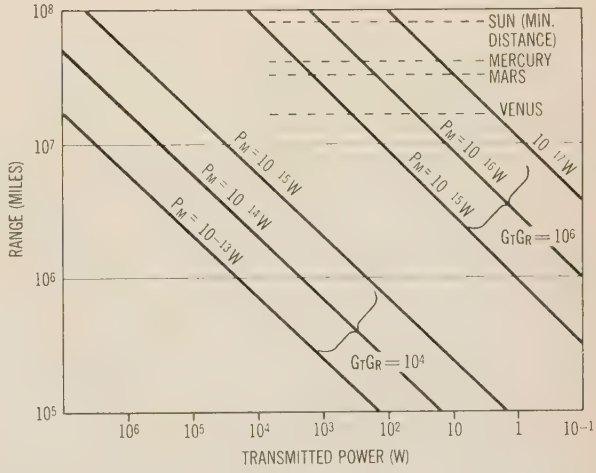

FIGURE 2: Range of one-way radio transmission at 50 mc. Range is equal to $[1.48 \times 10^2/f_{mc}\ (P_t G_T G_R/P_M,)]$ where G_T and G_R are the composite gain of the antenna and equal 10^4 (at 1000 ft per side) and P_M is the minimum power the receiver can detect and equal to $KTBN_f$ (losses) (integral losses), with T equaling 300 deg K, B equaling 10 kc, N_f equaling 3, and the total losses equaling 8. K is Boltzmann's constant.

people who might have the money to put it up.

The on-board transmitters would emit powers in the milliwatt range. The gain needed in the satellite is between 52-61.5 db. This is obviously too high to permit the use of a crystal video front end. You therefore must go to narrower-band preamps.

If you used an isotropic antenna, the required satellite transmitter output would jump to a watt. Even

more on next page

more important is that you would need 92 db of gain in the satellite receiver. This is almost as good as we can now do on the ground without worrying about getting the receiving system up into space.

The stabilization problems for the synchronous repeaters and the passive satellites are the same, as are the ground equipment requirements. You must know the orbit and you need a correction for the Doppler shift.

For the synchronous satellite you need automatic ground tracking that is looking in the right place once the satellite is put up. Therefore you must either place satellite in orbit with extreme precision or postpone the construction of the ground antenna until the satellite is out in space and you know exactly where it is. The satellite antenna would have to be stabilized within two degrees.

Communications to space vehicles

Now let us look briefly at the problem of communicating with a space vehicle from the earth. *Figure 1* shows some of its parameters. At a zero-decibel noise figure, it takes 20 dbw (decibels above one watt) to send one cycle with an omnidirectional antenna operating on 30 mc over the 10^8 miles to Venus or Mars. At 3000 mc, the power requirement jumps to a megawatt.

This power can be lowered, of course, if you use a non-isotropic antenna. For example, with a 60-ft reflector giving an antenna gain of 60 db, the required power at 3000 mc would drop back to one watt. However, in bringing down the power we have sharpened our beamwidth to 0.1 deg, which seriously adds to the tracking problem (*Fig. 3*).

The Doppler shift will determine how wide our bands must be for communication with a space vehicle. A craft going from the earth to Mars, for example, will have a shift—at some time during its transit—on the order of 106 cps/mc. At 3000 mc, that's 300 kc of bandwidth just to find the signal. *Figure 2*, which shows the 50-mc case, gives you an idea of the powers needed for space communications.

What about frequency selection in space? Once you get into space, there are no frequency restrictions. You can use redirected modulated sunlight or infrared or

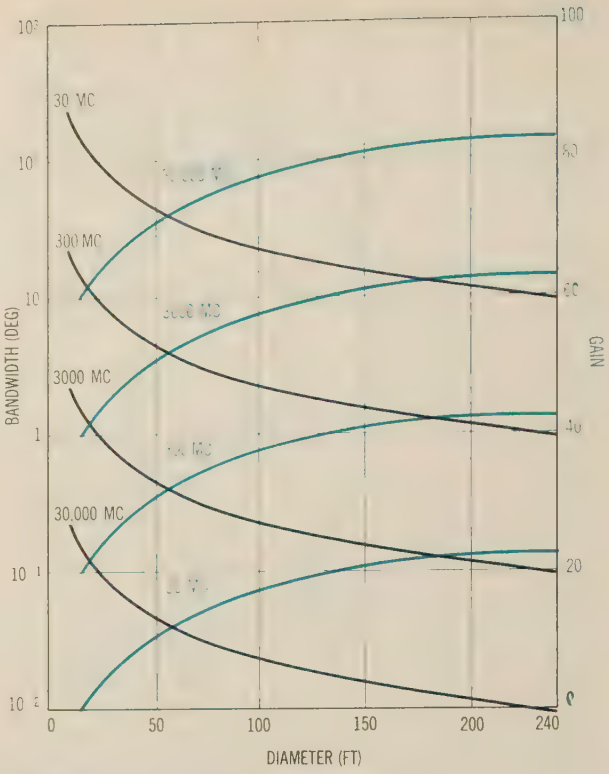

FIGURE 3: How large can parabolic antennas get? This graph shows, for instance, that, to get a gain of 42 db at 3000 mc, the parabola would have to be 25 ft across. The beamwidth would be slightly more than one degree.

radio waves. However, transmission times can be gigantic. If a vehicle was sent to the nearest star, which is 4½ light years away, not only would its signal take 4½ years to get back, but, if it were to contain any information, the power radiated from the point of origin would have to be tremendous. If, for instance, you looked at this star with an antenna as large as the entire earth, the beamwidth would still be such that you would see both the vehicle and the star will be in the beamwidth if the vehicle were less than 10^{13} miles away from the star. The vehicle therefore would have to produce as much RF power as the star emits over the bandwidth you would be using—something like 10^{32} W per cycle of bandwidth. That's not only well beyond the state of the art but actually more than the world's annual electric power output!

Another problem, which may eventually overshadow all the others, is acquisition. Before communications can take place between two vehicles, each must have the other within the beamwidth of its radiated energy. This could be achieved with a preplanned communications program: Vehicles would have to be at a certain place in space at a certain time to receive a message.

The alternative is to use the earth as a relay—all vehicles would send their messages to the earth with the proper address. An earth-based postal system which would be tracking all vehicles, would send the message on to the correct vehicle. A vehicle could send an inquiry to earth such as "Where do I look for vehicle No. 10?" The earth station would then look up the position of number 10 in its storage and transmit its position to the inquiring vehicle.—End

Power Requirements per Link of Passive Satellite Communications System

Sphere Diameter (ft)	Diameter of 20-Deg Spherical Section (ft)	Bandwidth (cps)*
1000	174	552
2000	348	6210
4000	695	24,840
6000	1045	53,900

*With 60-kw ground transmitter and 60-ft parabola at two-kc frequency, six-decibel noise figure, and 10-db ground receiver S/N ratio.

New ferrite phase shifter paves way for

inertialess scanning radar

This is the first article in a two-part series reporting on what is believed to be the first truly inertialess, two-plane scanning antenna. It discusses the antenna's key element, an axial ferrite phase shifter. Next month's article will explain how this shifter is applied to a pencil beam radar.

by F. E. Goodwin and T. A. Nussmeier,
Experimental Systems Section, Research & Development Laboratories, Hughes Aircraft Co.[1]

THE PHASE SHIFT property of microwave ferrites has long been considered the key to inertialess scanning of radar antennas. Until recently, the bulkiness of "designable" ferrite shifters made the idea somewhat impractical. High intensity magnetic fields (transverse to the ferrite-loaded waveguide) were needed for bias. To get these intense fields, the designer had to resort to bulky components in the form of iron magnetic circuits, iron pole pieces, and large field coils.

Fortunately, a way has now been found of getting the necessary phase shift from the ferrite elements without large driving fields. Studies by Reggia and Spencer show that you can phase-scan an antenna by applying weak

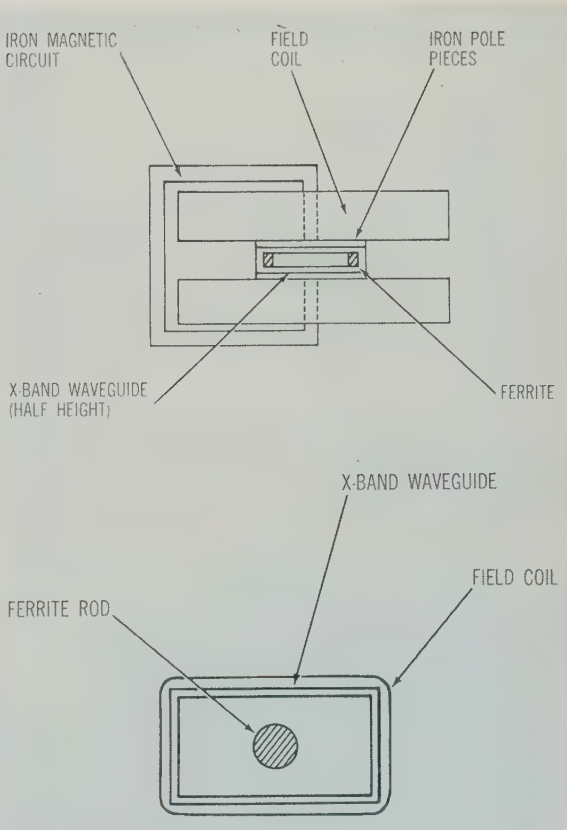

FIGURE 1: Transverse (top) and axial (bottom) field phase shifters. The new axial-field type is smaller, lighter, and has a lower driving requirement.

(1) Research & Development Laboratories, Hughes Aircraft Co., Culver City, Calif.

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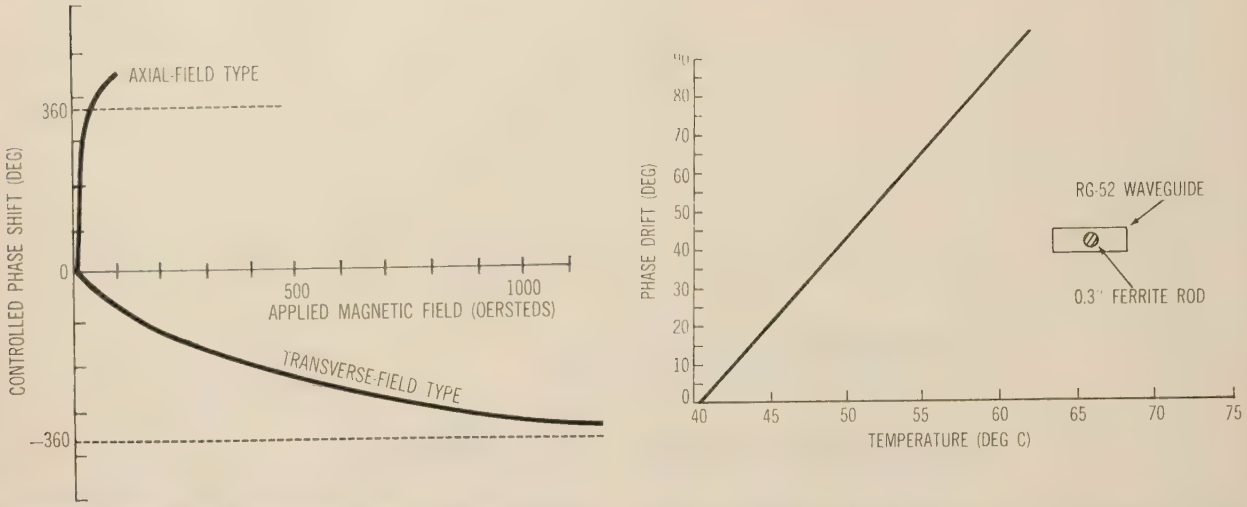


FIGURE 2: Phase-shift sensitivity (left) of phase shifters as a function of the applied magnetic field. Center: Phase drift vs temperature for a 5.7-in., 0.3-in.-diameter circular rod where the frequency is 8820 mc and $d\phi/\alpha T = 4.25$

axial fields to a ferrite-loaded waveguide. While this approach has not yet been confirmed in all its aspects by actual application, it does appear to be the break we have needed to make electronic scanning practical.

Using the axial-field approach, Hughes Aircraft, in a joint effort of the Ferrite Section of its Microwave Lab and the Experimental Systems Section of its Electronics Lab, has developed a ferrite phase shifter and successfully applied it to a bilateral radar. This device, of course, first of all had to meet the basic requirements for any phase shifter:

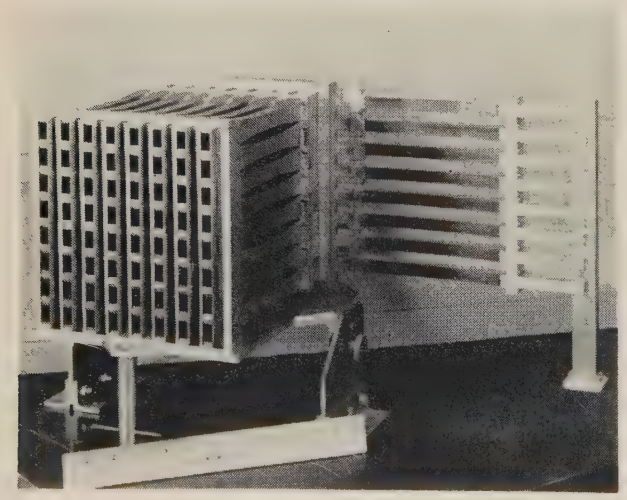
- reciprocity (necessary if the antenna is to be used for transmission and reception),
- high speed switching (for rapid beam scanning),
- low driving power (needed for large arrays),
- high RF power handling capability,
- simplicity and compactness (for easy fabrication).

The older, transverse-field type of ferrite has the disadvantages of large size (about 4x4x8 in.), high weight (about five pounds), and of a driving requirement of about 1500 amp-turns (*Fig. 1*). The new, axial-field type measures only about 1x2x8 in., weighs only half a pound, and needs only 160 amp-turns to produce a minimum phase shift of 360 deg. The reduction of almost 90 per cent in ampere-turns is particularly important—it means a much smaller field coil, with much lower inductance (*Fig. 2*).

Both transverse and axial ferrites are temperature-sensitive, because of the inherent properties of existing ferrite materials. So temperature must be controlled, regardless of the magnetic configuration.

Hysteresis effects are present in both types of phase shifter. As the axial-field type is operated below saturation, hysteresis may occur within the ferrite itself. The transverse type uses fields far above saturation, so there are no internal hysteresis effects—but "external hysteresis (from the iron magnetic circuits) must be reckoned with.

PHASE-SCANNED array during assembly. Beam is independently controlled in elevation and azimuth by two ferrite phase shifters.

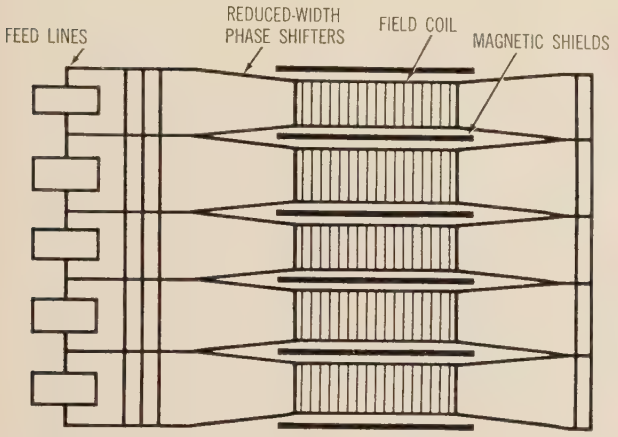


Hysteresis must be considered

With either type of phase shifter, therefore, hysteresis has to be considered in programing the shifter. The discovery of ferrites with extremely narrow loop ferrites, though, may eventually eliminate this requirement for the axial-field type.

Perhaps the most important advantage of the axial-field ferrite is that it can be switched very quickly from one phase setting to another.[2] If we arbitrarily assume a maximum switching time of 10 usec, we can qualitatively estimate the maximum inductance tolerable in the driving coil of the phase shifter. If we further as-

(2) To get this short switching time, measures must be taken to reduce eddy currents in the waveguide.



deg/deg C. Right: Reduced-width phase shifters magnetically isolated in the H-plane.

sume that the transient circuit voltage is 500 V (the steady-state supply would be much lower) and that the current reaches 99 per cent of its final value within 10 usec, then we get:

$$i(t) / I_o = 1 - e^{-t/\tau} = 1 - e^{-Rt/L} = 0.99,$$
$$e^{-t/\tau} = 0.01, \tau = L/R = 10/ln\ 100 = 2.2\ usec.$$

The effective resistance in the driving circuit depends on the transient voltage and the maximum control current. The values then parameters, although arbitrary, have practical limits. If a maximum driving current of one ampere is assumed, then:

$$L = 1100\ uh\ (max).$$

An experimental driving coil with 30 oersteds (more than enough for the required phase shift) has an inductance of 700 uh, we found. Since this is within the maximum practical limit, our configuration more than meets the maximum switching time requirement. In experiments made to verify the switching time, we found that the operating inductance in effective was some 300 uh less than the zero current inductance, since the ferrite was partially saturated during operation. In this way, we get faster switching than we had expected. Incidentally, the phase shifter can be switched within 10 usec if transistor circuitry is used and in less than one microsecond if a conventional but higher power current source is used.

By thermostatic control of the waveguide temperature, phase drift due to ambient changes can be eliminated. However, the RF power dissipated in the ferrite rod will raise the rod's temperature above that of the surrounding waveguide. A circular rod, for example, can dissipate 0.6 W without causing excessive phase error. If this power were dissipated in a 0.3-in.-diameter, 5.5-in. long ferrite rod, the temperature of the rod would rise by one degree C and the resultant phase shift would be 4.5 deg (*Fig. 2*).

The insertion loss due to the power dissipated in the guide, limits the average power transmitted through the

more on next page

Table I:
Maximum Insertion Allowable Loss for Temperature Stability at Various Incident-Power Levels

Average Incident Power (W)	Maximum Insertion Loss (db)	Average Transmitted Power (W)
1.0	4	0.4
1.5	2.2	0.9
2.0	1.6	1.4
2.5	1.2	1.9
3.0	0.95	2.4
4.0	0.7	3.4
5.0	0.55	4.4
6.0	0.45	5.4
7.0	0.4	6.4
8.0	0.32	7.4
9.0	0.28	8.4
10.0	0.26	9.4

Table II:
Figures of Merit and Limiting Power Levels for Various Ferrites

Material	Figure of Merit (deg/db)*	Input Power Level at Which Limiting Occurs (kw)
Ferramic R-1	430	2.5
Ferramic R-4	220	0.8
Hughes Series 52	85 (0.27-in. rod)	25
Hughes Series 24	120 (0.245-in. rod)	20
Trans-Tech 390	252 (0.27-in. rod)	5
Trans-Tech 414	0	—
Airtron FN-102	110	20
Airtron FN-180-2	3	—
Airtron FN-199-4	2	—
Ferroxcube 106	10	30

*Measured at 4 kw peak, 50 oersteds, and 8.65 kmc. Unless otherwise noted, all samples were 0.3 in. in diameter and 2.5 in. long.

Table III: Practical Limits of the Axial-Field Ferrite Phase Shifter Using a Circular R-1 Ferrite Rod

Maximum peak power (input)	2.5 kw
Maximum duty cycle (at 2.5 kw peak)	0.001
Maximum average power	2.5 W
Maximum insertion loss	1 db
Maximum phase shift due to heating	5 deg
Temperature regulation at 50 deg C	±1 deg C
Driving current (maximum)	1 amp
Easily obtainable switching time	10 usec

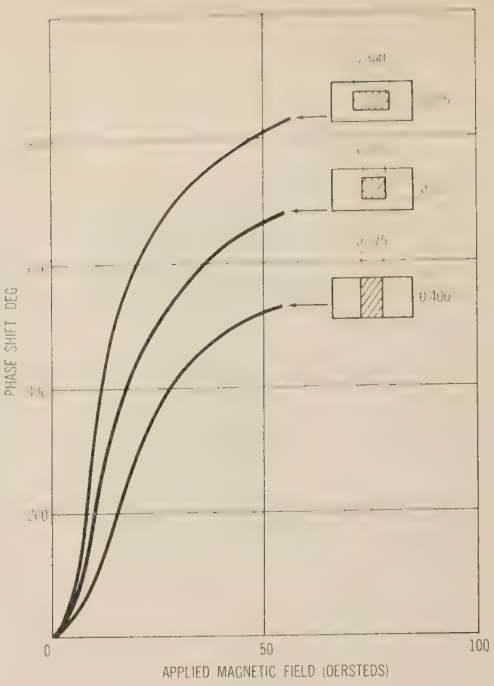


FIGURE 4: Phase shift vs applied field for three ferrite configurations using R-1 slabs 5.75 in. in length (including taper).

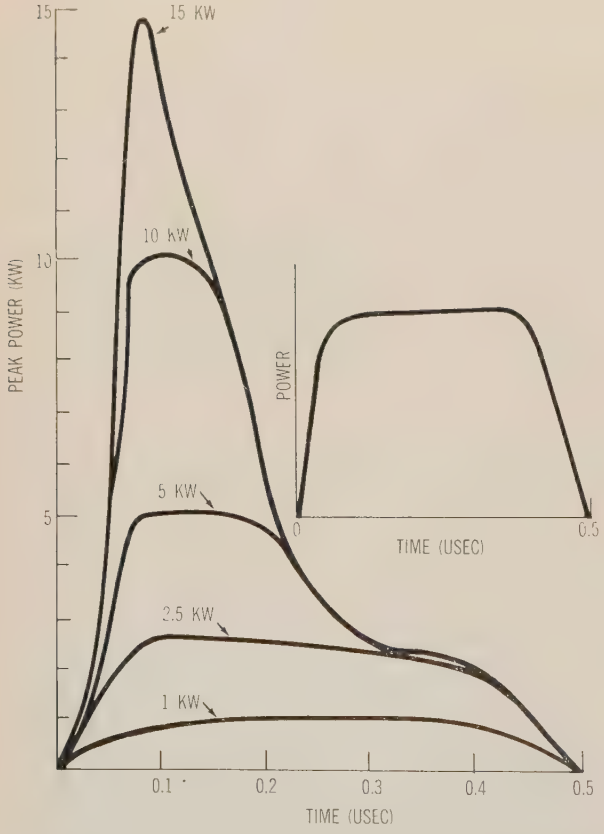


FIGURE 3: Power transmitted through an R-1 ferrite-loaded phase shifter and the incident pulse shape for all power levels (top).

guide. *Table I* shows the maximum allowable insertion losses for various average input power levels.

Insertion loss is a function not only of the ferrite configuration but also of the peak input power to the phase shifter. The latter's "limiting" effect occurs at different power levels with different ferrite materials. *Table II* shows this effect for several ferrites, whose figures of merit—degrees of phase shift per decibel of loss—are also given.

Despite the fact that it "limits" at 2.5 kw, the Type R-1 ferrite proved to have the best figure of merit among the types we tested. *Figure 3* shows the amount of power transmitted through an R-1 phase shifter at various power levels. Note that a spike of energy at the leading edge of the pulse is transmitted practically unattenuated.

If R-1 is used, you can reasonably set an upper limit of 2.5 kw peak power. *Table III* lists the practical operating limits.

"High power" R-1 dissipates only 0.6 W

The single drawback of R-1 is that it is a "low power" ferrite. However, even if it were possible to design a "high power" version of R-1—which would have no limiting effects—at 0.3 in. diameter and 2.5 in. length it still could not dissipate more than 0.6 W average power. And for a one-decibel insertion loss, the average power could not exceed three watts for the duty cycle that produced the results shown in Table *II*.

The half-watt improvement from 2.5 to three watts is hardly significant. Even at optimum performance, the inherent limits of the configuration we're dealing with are obvious. To make that improvement at all meaningful, the higher power would have to be accompanied by a lower insertion loss.

As we began design of an improved ferrite phase shifter, we decided that a large part of the ferrite element should be in thermal contact with the waveguide

wall. Of the various configurations that we tried out, three proved to be of interest (*Fig. 4*).

Using the waveguide walls as a heat sink greatly reduced the temperature stabilization problem. Measurements showed that almost three watts could be dissipated in the ferrite before its temperature increased by one degree C.

In a thin-wall waveguide, the ferrite element needs a relatively low field, so a small inductance field coil can be used. However, the shorted-turn effect of the brass waveguide kept us from attaining switching times on the order of a few microseconds, which otherwise would have been possible.

The Maxwell relation explains this situation:

$$\nabla \times \vec{E} = -\partial B/\partial t.$$

The B-field cannot be increased rapidly within the waveguide without generating circular currents around the conducting perimeter. An interior-plated ceramic waveguide lends itself to very fast switching. Most ceramics are poor heat conductors, however, and regulating the temperature of the ferrite through a ceramic waveguide is difficult. As a compromise, you can use full-thickness brass walls on top and at the bottom, to be in contact with the ferrite, and thin side walls. This method in our case provided both fast switching and temperature control (*Fig. 6*).

For the application we had in mind, it was necessary to reduce the width of the phase shifter in the region of the field coil. Studies of the RF field distribution in the loaded guide show that most of the RF energy is concentrated in or near the ferrite. The width of the guide thus may be reduced from 0.9 to 0.5 in. without adverse effects on the phase shift characteristics. This reduction makes it possible to locate the units right next to each other in an array without magnetic interaction (*Fig. 2*).

The design of the phase shifter for the all-ferrite scanner was optimized for operation over a one per cent frequency band. Further modifications were made later to allow for operation over a 10-per cent bandwidth.

The frequency sensitivity of a ferrite phase shifter depends on the unit's configuration and material. In electronically scanned antennas, the phase shifter should be completely independent of frequency. Frequency sensitivity is especially undesirable when the phase shifter is to be used with antennas scanned in one plane by varying the frequency.

The scan angles of such an array (as measured broadside) are given by:

$$\sin\gamma = \theta/Kd + \phi/K \text{ (phase scanning)},$$
$$\sin\mu = \phi D/Kd \cos\gamma \text{ (frequency scanning)},$$

where ν is the frequency-scan angle; μ, the phase-scan angle; d, the element spacing; and θ and ϕ are the uniform progressive phase shifts in the phase-scanned and frequency-scanned planes, respectively.

"Squint" is introduced in ν-plane

Figure 5 plots the scan angles from these equations. Frequency scanning in μ introduces a "squint" in the ν-plane, because of the frequency dispersion in the main feed array. This effect corresponds to ϕ/K in the ν-equation.

Since "squint" is inherent in frequency-phase-scanned arrays, it would seem at first glance that further dispersion due to phase shifters would not raise any particular problem. This is in fact true for continuous, progressive phase shift in the ν-plane (i. e., when no recycling of the phase shift is allowed). In this case, additional "squint" is introduced because of the greatly increased electric length of the phase shifter at one end with respect to the other end, but no pattern deterioration results.

However, continuous progressive phase shift in a large array is impractical. Ferrite phase shifters in particular, since they have only slightly more than 360 deg of controllable phase shift at reasonable losses, must be recycled many times for wide-angle scanning in a large array. This recycling introduces phase errors at the radiating slots.

For a phase shifter consisting of a waveguide that is a centimeters long and filled with a medium whose propagation parameters are functions of the applied magnetic field and the frequency, the phase error between two adjacent elements equals:

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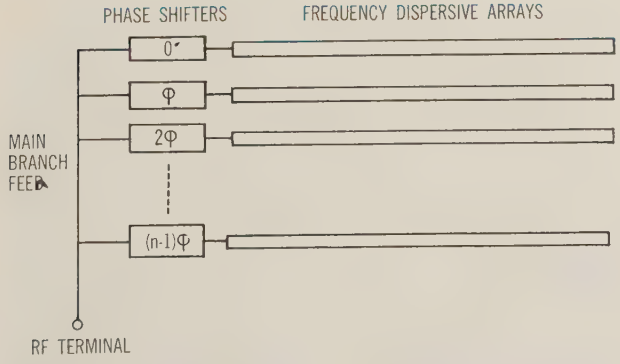
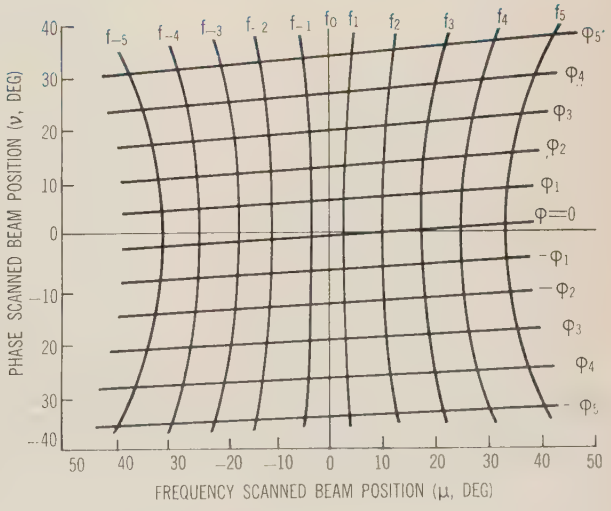


FIGURE 5: Characteristics of phase-frequency scanning.


PHASE SCANNED BEAM POSITION (ν, DEG)
FREQUENCY SCANNED BEAM POSITION (μ, DEG)
f-5 f-4 f-3 f-2 f-1 f0 f1 f2 f3 f4 f5
Φ5 Φ4 Φ3 Φ2 Φ1 Φ=0 -Φ1 -Φ2 Φ3 Φ4 -Φ5
40 30 20 10 0 -10 20 30 -40
50 40 30 -20 -10 0 10 20 30 40 50

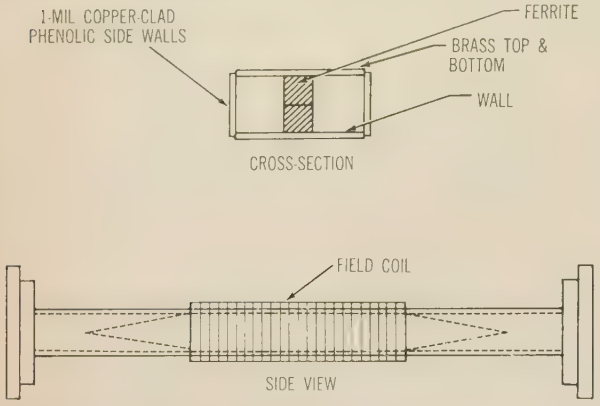


FIGURE 6: Axial-field phase shifter modified to improve thermal stability and switching speed.

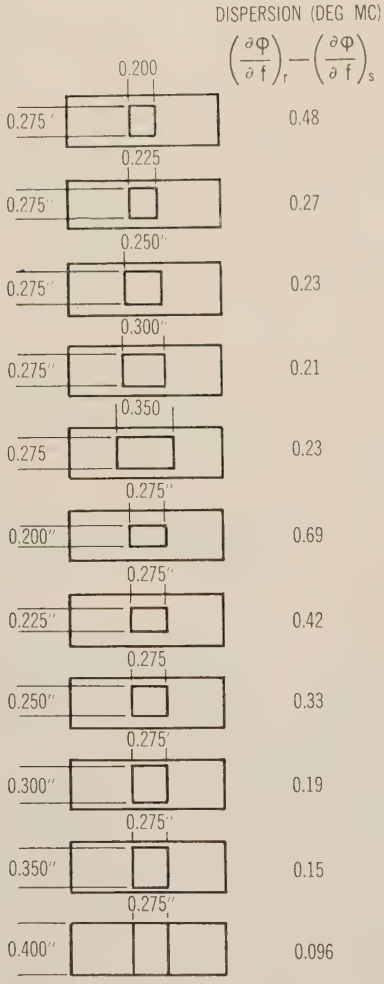


FIGURE 7: Frequency sensitivity of various ferrite configurations using a General Ceramics R-1 ferrite. The configuration at the bottom was chosen by Hughes.

$$\phi_s = 360a\ (\Delta f/f)\ (1/\lambda_{Pr} - 1/\lambda_{Ps})\ deg$$

The error is due to the difference in rate of change of phase with change in frequency between adjacent (r^{th} and s^{th}) phase shifters.

This error arises whenever recycling occurs. As we can see, if the wavelength of a section of waveguide is changed in order to shift the phase, then there is no way to recycle the phase shifters without introducing this error. The error occurs whether the phase shifter is a ferrite or a dielectric.

Some ferrites have the unusual property, however, of a nearly constant RF energy wavelength over a considerable frequency band. The wave velocity within the medium in these cases is nearly proportional to the frequency:

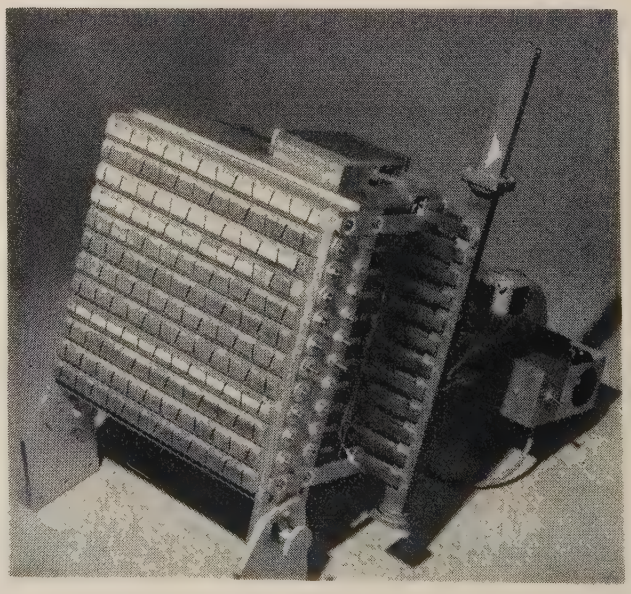
$$\partial\phi_r/\partial f \approx 0,\ \partial\phi_s/\partial f \approx 0.$$

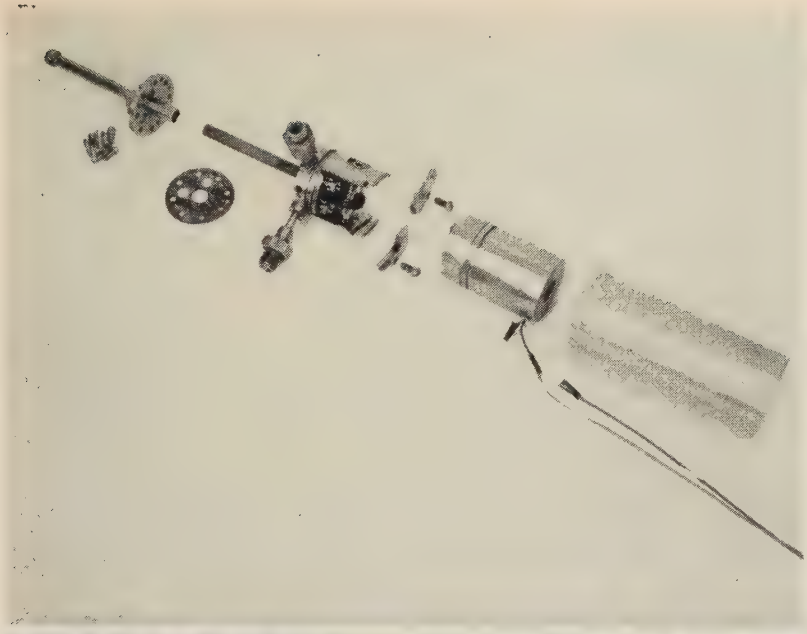
The phase factor of a nickel-zinc ferrite in an unbounded medium as a function of frequency approaches the ideal. Analysis predicts that a negative slope of this curve proportional to $-1/f^2$ produces a wavelength in the medium that is constant for all frequencies. The two curves closely coincide over most of the band. Obviously nickel-zinc would be advantageous in broadband applications.

Unfortunately, the R-1 ferrite does not have the desirable negative slope and is more frequency-sensitive than nickel-zinc ferrites. Many experiments show, though, that a phase shifter using R-1 can be designed with a variety of frequency characteristics that depend on the ferrite geometry (*Fig. 7*).

The design of the phase shifter for our all-ferrite scanner was simplified because a fixed frequency was to be used. In choosing our configuration (*Fig. 7*), we mainly considered fabricability, thermal regulation, and efficiency of driving. This configuration is also less frequency-sensitive than any other tested by us. When made of nickel-zinc, we expect our ferrite to be almost insensitive to frequency.—End

FREQUENCY-PHASE-SCANNED array. Twelve ferrite phase shifters (shown folded behind the main array) are used in the main branch feed line to position the beam in elevation. The beam is scanned in azimuth by programed frequency changes.





EIGHT-OUNCE "MinIRcooler," a single-stage mechanical refrigerator, works reliably at well below 77 deg K (liquid N_2). Yet the cooling head can be handled during operation—only the business end that fits into the dewar gets cold. Top: Head fully dismantled.

design digest

by Bernard Kovit
Associate Electronics Editor

IR cell cooler extends detection ranges

MINIATURE IR cooler conceived by Arthur D. Little, Cambridge, Mass., and produced by Hamilton Standard Div., United Aircraft Corp., Windsor Locks, Conn., has operated at well below 60 deg K in single-stage form. The device operates on the basis of regenerative precooling of a relatively low pressure gas, such as helium, and the performance of work by the gas during expansion. Ham-Stan's cooler uses only one-sixth the pressure (300 psi) of present Joule-Thomson coolers, has less bulk and weight, and works in a closed or open cycle. The advantages of reliable, sustained, cooling apply to many materials that benefit from, and in some cases depend on, below-liquid-N_2 cooling. Examples are certain solid-state masers, cryogenic computer elements, and various IR detectors. In particular, detection in the 8-13-unicron window is improved. The opening up of the 15-40-micron wavelengths for space operations may prove to be the device's biggest achievement. Write in No. 75 on Reader Service Card for more information.

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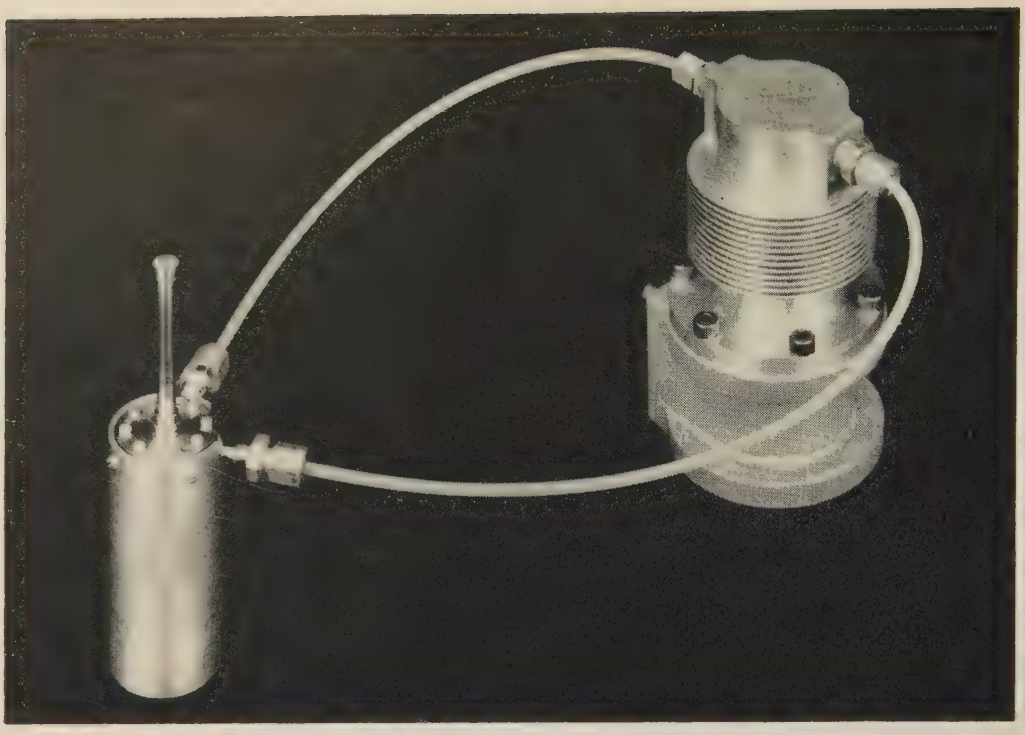
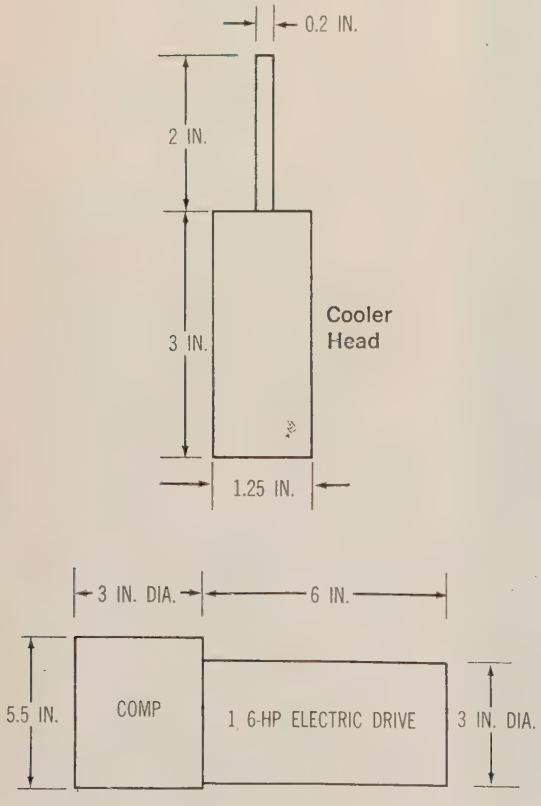
design digest

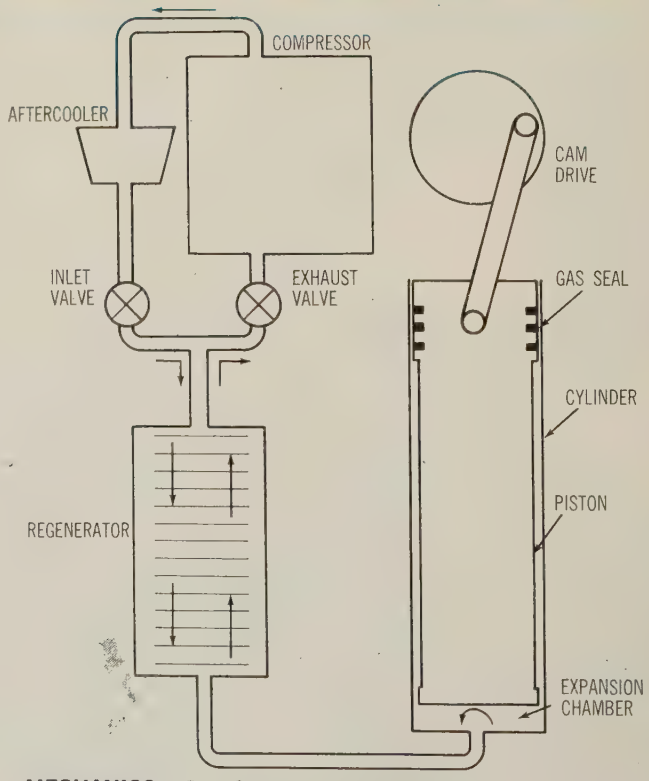


CLOSED - CYCLE system consisting of refrigerator (left) and compressor operates with only 300 psig. Several coolers can be operated from one compressor (shown here without its motor).

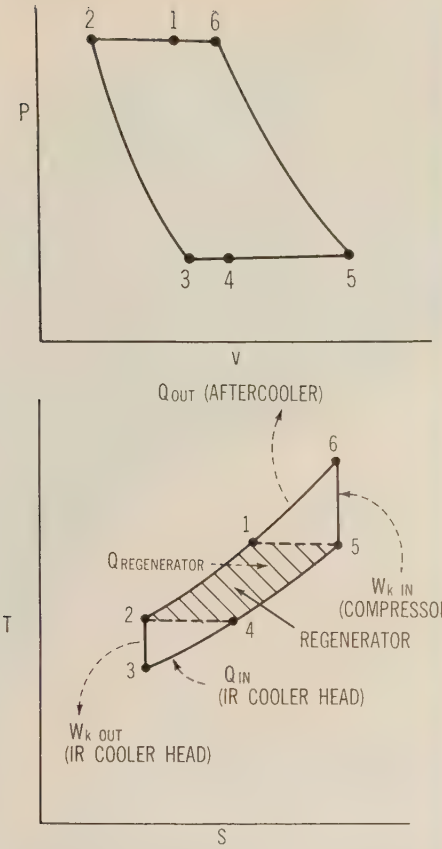
MinIRcooler Dimensions



Compressor



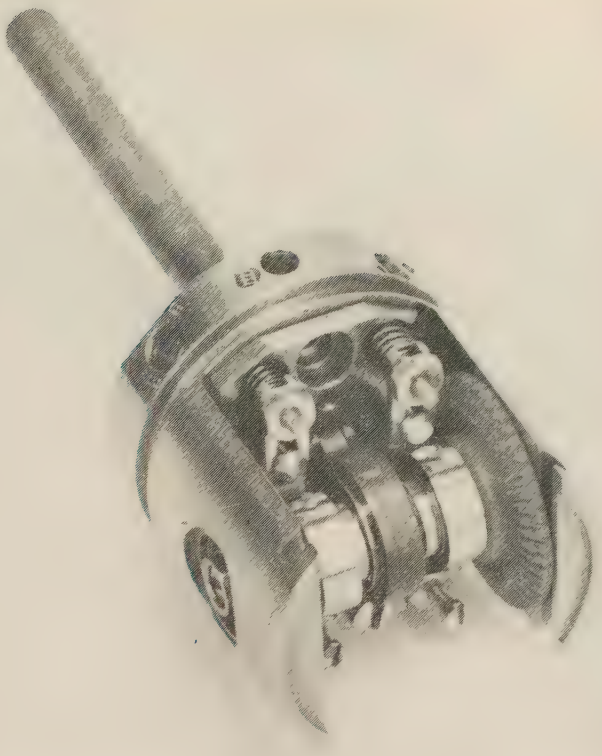
MECHANICS—Gas from a dry-helium compressor is admitted intermittently into the cooler through a mechanically operated inlet valve and a thermal regenerator. The piston, loosely fitted except at the seating ring, moves freely but with controlled lengthwise travel. After expansion, gas is regenerated and exhausted back to the compressor. Unique feature of process is rejection of enthalpy as heat rather than as work to the exterior.

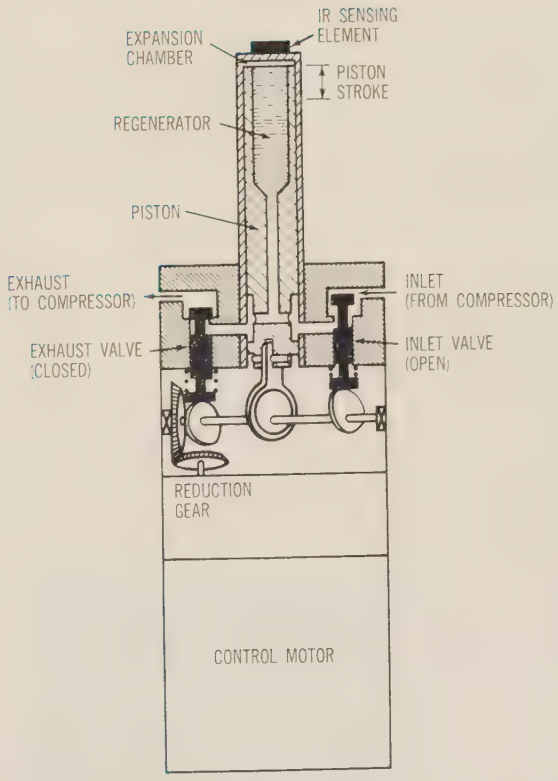


THERMODYNAMIC cycle (where P is pressure; v, volume; T, temperature; S, entropy): Process 1-2—Piston is set for minimum chamber volume. Inlet valve opens and piston is displaced (timing motor) to increase volume. Discharge gas from compressor is drawn in through regenerator where it's cooled at constant P. 2-3: Gas in chamber is made to expand isentropically by closing valve as piston recedes. Expanding gas does work on piston, expending its own energy and thus lowering T. 3-4: Gas cools IR cell at constant P. 4-5: Expanded to discharge pressure, it's forced back through regenerator—removing latter's heat—and out exhaust valve by returning piston. Ideally, this heat would equal that added during 1-2. 5-6: Exhausted low-P gas is compressed.

TYPICAL IR APPLICATIONS

Element	Optimum Temp (deg K)	Cutoff Wavelength (μ)
Ge-Au (P type)	60-65	10
Ge-Au:Sb	78	5.5
Ge-Zn:Sb	50	15
GE-Sb	2	20
Ge-As	2	200
SiGe-Au	4	20
PbSe	<77	8
PbTe	77	6
InSb	<77	16





PROTOTYPE shows cooler's production details. Serious problem might be gas leakage past Teflon sealing ring were latter not at room temperature. Piston is of micarta. Regenerator is 0.093-in. hole bored in piston and filled with stacked brass-wire-cloth punchings. Unit shown operated continuously from commercial supply. Running at 60 deg K, it proved resistant to condensible impurities.

This is an actual photograph of 1½" Springfield "400" hose.

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Target-plus-symbol display simplifies ATC radar tracking

ATC radar operators have an unenviable job in tracking multiple targets in congested areas. This article shows how their lot could be made easier by continuous identification of PPI radar targets. By easing the controller's burden, such identification naturally also would make for safer flight operations.

by Abe Shulman and Marvin Bernstein,
Senior Engineers, Radar Group Airborne Instruments Laboratory Div., Cutler-Hammer, Inc.*

HOW can the target tracking problems of air traffic control radar operators in congested areas be reduced? One remedy is to identify or codify all the targets on the PPI display throughout the tracking sequence. Using such an approach, Airborne Instruments Lab has developed a track-while-scan system that displays identifying symbols near each target. The operator now can clearly distinguish between target and do a more accurate job of controlling rapidly changing situations in the terminal area.

In general, the same symbol remains with a target throughout the tracking period. However, provision

* Airborne Instruments Laboratory Div., Cutler-Hammer, Inc., 160 Old County Rd., Mineola, N.Y.

more on next page

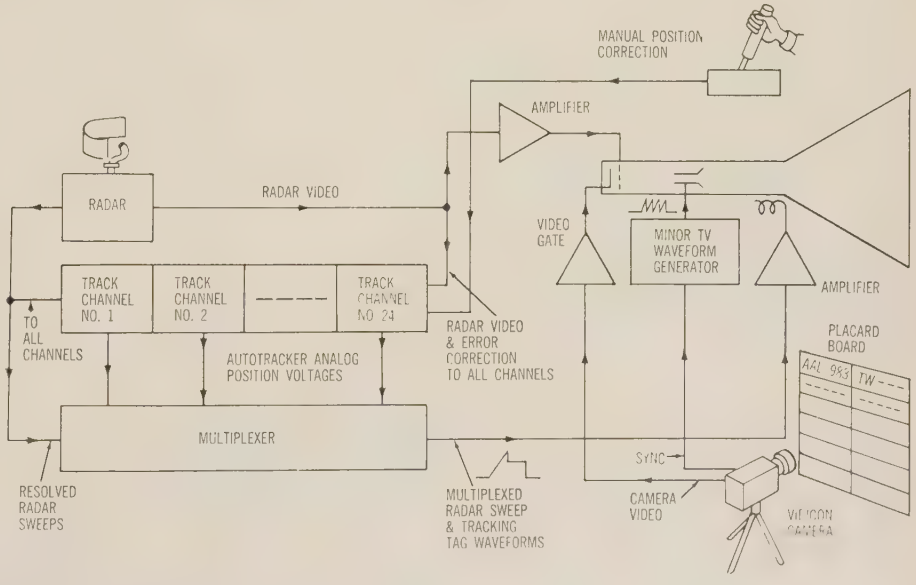

FIGURE 1: Track-while-scan radar-and-symbol display system is made up of a radar set and 24 Cartesian-analog precision autotracking channels.

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is made for indications of changes in altitude and/or speed when these are needed by the operator.

Our system's design is based on the intensity modulation of the PPI kinescope with symbol-video signals from a closed-circuit TV subsystem. This modulation takes place during the radar dead time, while the PPI beam is deflected in the vicinity of the target to be identified. At the same time, minor TV scanning waveforms are applied to auxiliary electrostatic deflection plates in the PPI scope to display the symbol video.

24 symbol formats are used in the system

The system uses 24 symbol formats, each consisting of a circle tag surrounding the target and six alpha-numerical characters or equivalent information. Scan-converted radar displays are also included in the system.

Figure 2 shows the two types of display used in the system as well as the deflection waveforms. The combined radar-and-symbol display presents an 80-mile PPI radar sweep at a nominal repetition rate of 360 cps. The symbol waveforms interlaced in the radar dead time generate circular tags about the targets being tracked. Minor TV rasters are produced by gated sawtooth waveforms immediately following the circle-tag interval. Also at this time, the alphanumerical video is gated on to display the characters.

The *Table* explains the sequence of a complete radar repetition cycle of the CRT beam in the radar-and-symbol display and the steps of a major TV cycle of the beam in the scan-converted-and-symbol display. *Figure 1* shows how the radar-and-symbol display is produced.

The memory stores can be corrected by hand

Basically you have a complete radar track-while-scan system made up of a radar set and 24 Cartesian-analog precision autotracking channels. The system includes provisions for precise multiplexing of channel analog memory stores and interlacing with resolved radar sweep waveforms. The memory stores can also be corrected manually for errors that are detected visually on the display.

Each autotracking channel stores

more on page 144

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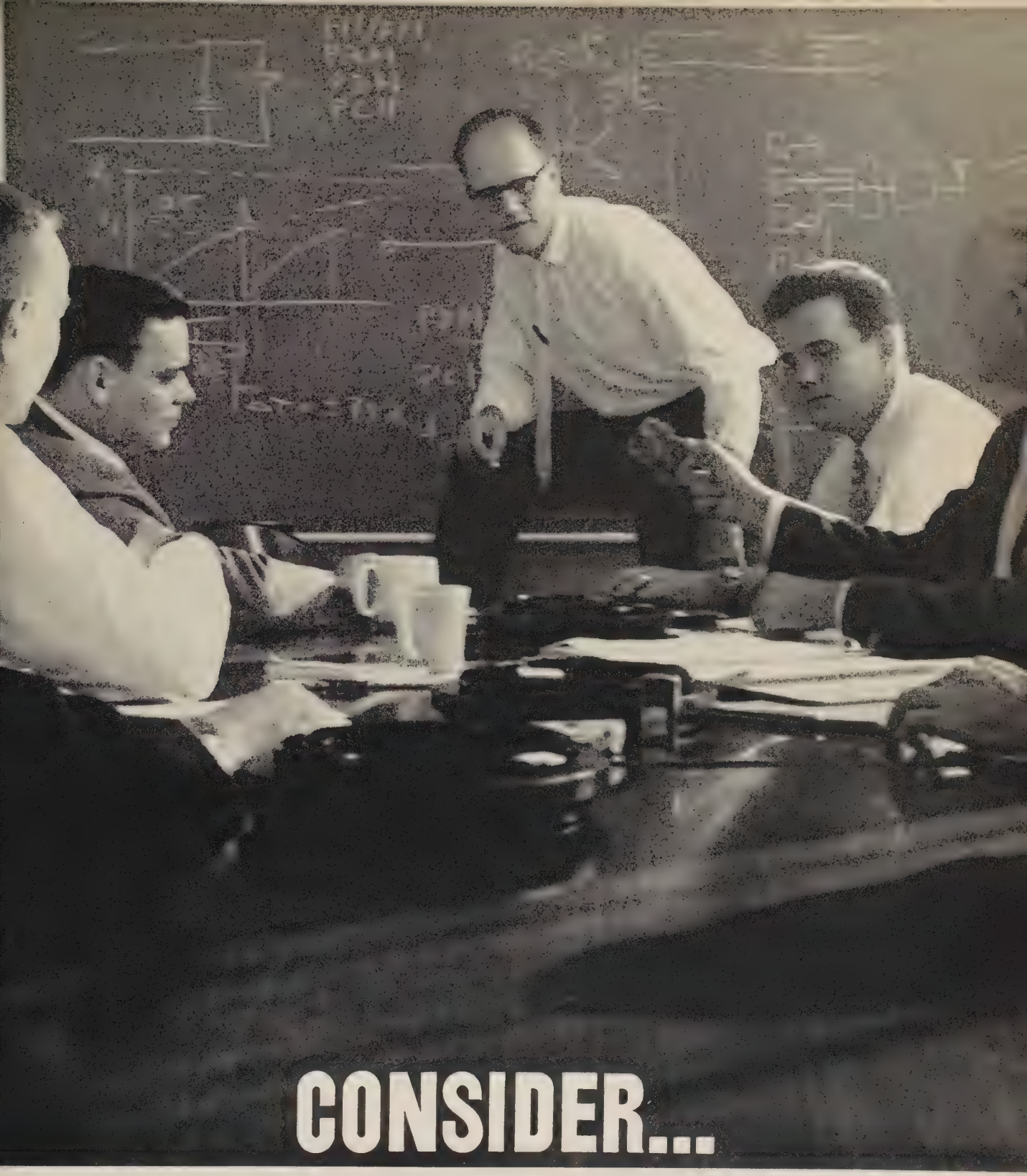

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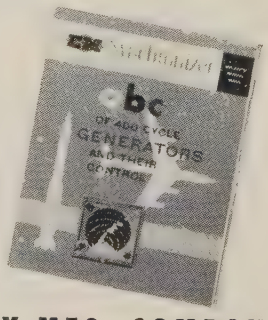

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Radar-and-Symbol Display Cycle

(1) CRT beam is intensified as it sweeps linearly from screen's center to periphery, making one 80-mile radar sweep.

(2) From screen's periphery, beam slews rapidly to a target position without being intensified.

(3) Beam is intensified as it traces small circle around target. Small sector of circle may be blanked to show when autotracking facility of associated tracking channel is not used.

(4) Completing circular motion, beam traces out 15 lines of an interlaced 30-line minor TV raster while being intensified by alphanumerical video.

(5) After tracing 15th line, beam slews rapidly back to screen center to await next cycle.

(6) Twenty-four symbol-identified tracking tags are displayed successively, each at an independent position determined by a tracking channel.

Scan-Converted-and-Symbol Display Cycle

(1) CRT beam slews rapidly from lower righthand corner of display to screen center without being intensified.

(2) From screen center, beam makes 12 successive radar sweeps (in 1/30 sec). Each sweep is exactly as in the radar-symbol display, except that the radar sweeps are not intensified. During this interval, only circle-tag and alphanumerical formats are displayed.

(3) Concluding the 12 radar sweeps, the beam slews rapidly to upper left corner and, in the next 1/60 sec, makes one 312.5-line field of an interlaced 625-line frame that displays scan-converted radar video.

(4) The 312.5-line field ends at lower righthand corner, where cycle starts again, except that the remaining 12 circle tags and the alternate TV field are then presented.

—in analog form—the Cartesian-resolved position of one radar target being tracked. Radar video and resolved radar sweep waveforms in the channels are combined to produce small automatic corrections in the stored position information. When relatively coarse adjustment is required, the operator can manually operate a track stick (provided at each display). To give him a direct visual indication of tracking errors, each autotracking channel position is displayed in the form of a circular tracking tag around the target.

k With the vidicon camera and a placard board, the symbol formats in the placards are superimposed onto the tracking tags. There's enough time for such a presentation because the circle tag only takes up to 200 of the 1780 usec

more on page 147

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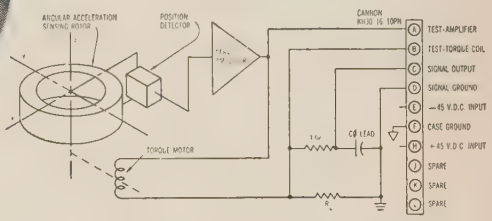

Operational diagram of Donner's new Model 4525 Angular Accelerometer.

Donner's rugged new angular accelerometer weighs only 2 pounds.

The Specs

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LINEARITY 0.1% full scale
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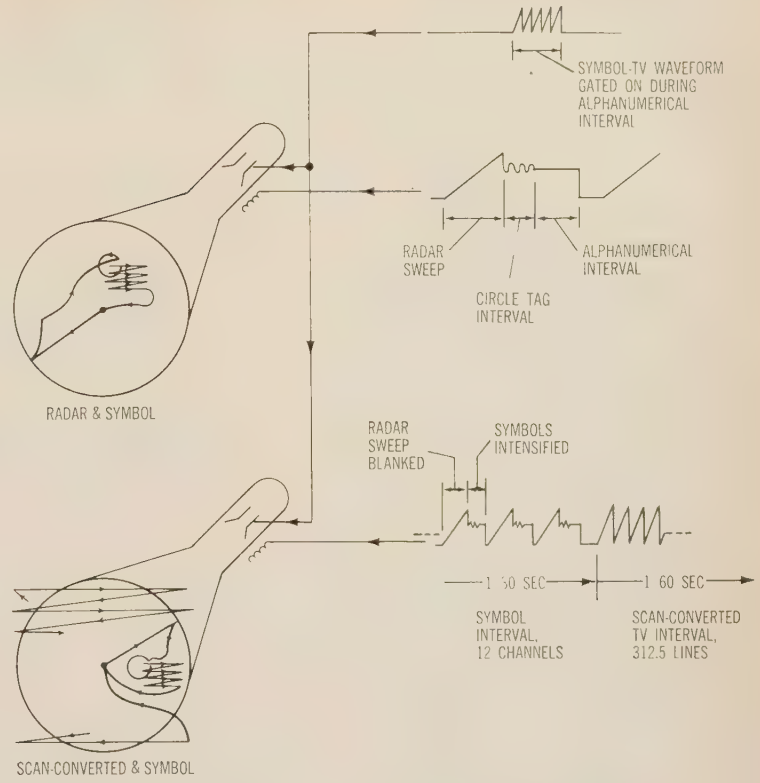

FIGURE 2: Radar-and-symbol and scan-converted-symbol displays.

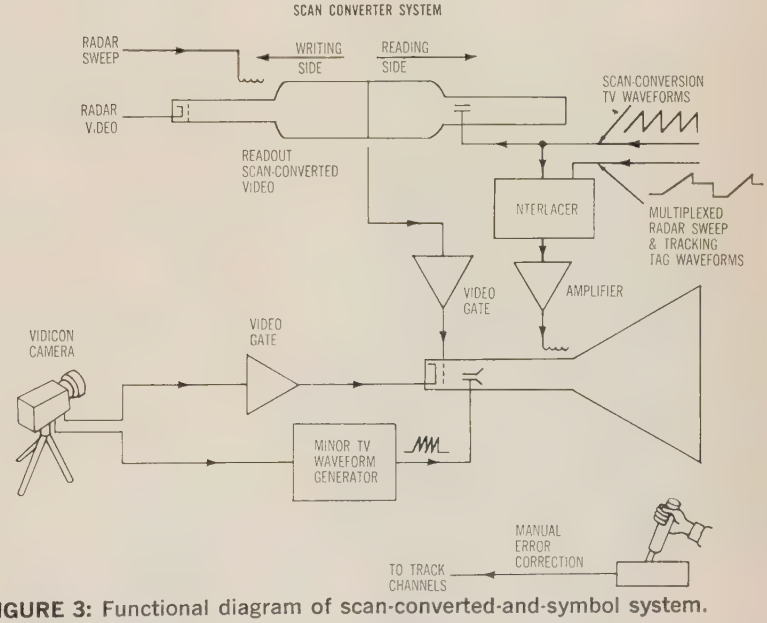

FIGURE 3: Functional diagram of scan-converted-and-symbol system.

of radar dead time. In the remaining 1580 usec, the vidicon camera can scan through at least one-twelfth of a vertical scan. By applying to the display kinescope minor TV waveforms synchronized with the camera scan, the camera video derived from a placard can be displayed at the position of a tracking tag.

Actually, the minor TV waveforms are produced by a waveform generator synchronized with the horizontal scan rate of the camera. The waveforms are fed to auxiliary electrostatic deflection plates in the neck of the CRT just ahead of the conventional magnetic-deflection assembly. The rapid horizontal TV rate can therefore be presented to a kinescope that has a relatively slow magnetic-deflection yoke.

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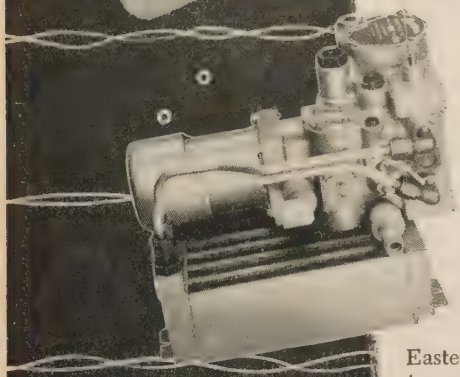

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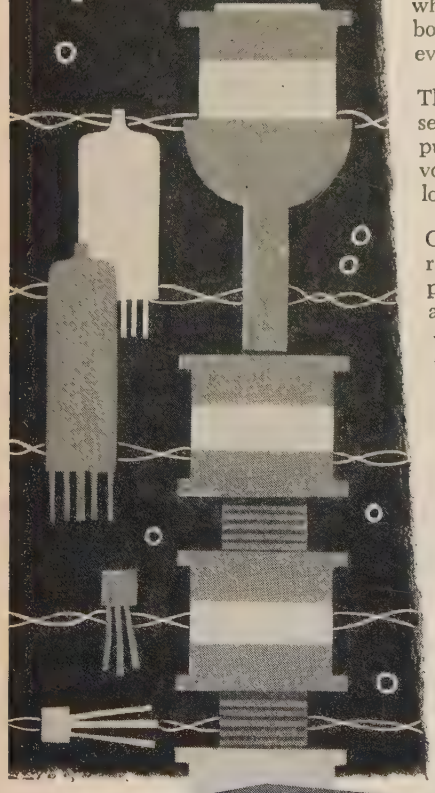
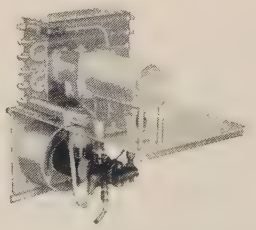
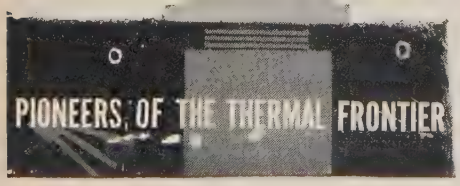




liquid cooling units for 50 to 50,000 watts dissipation



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system is the use of an alphanumerical TV system synchronized with the channel multiplexing rate, which in turn is synchronized with the radar system trigger. In this way, an alphanumerical format on the placard board can be scanned at the same time that its tracking channel is sampled by the channel multiplexer.

The TV camera continuously scans the entire placard board in the conventional way, and a particular placard is chosen by selectively intensifying the synchronized scan at the kinescope. This technique makes it possible to present the 24 different formats in the camera picture at the independent locations of the 24 tracking tags on the radar-and-symbol display.

Displays are operated in two consoles

For a compatible integration, the scan-converted-and-symbol displays are operated in two separate consoles with modified magnetic-deflection systems. These consoles are used in addition to the two used to present radar-symbol displays, so that you have a total of four concurrently operating consoles.

The scan-conversion system is based on the French Intec TI-440 scan-converter unit, which converts a PPI picture to TV in a 625-line frame. The heart of this unit is the TMA-403X scan-converter, a storage tube that reads and writes simultaneously. Such characteristics as controllable persistence and high resolution make the TMA-403X an extremely advantageous device.

Figure 3 shows the TMA-403X with a writing beam impressing the radar PPI picture on one side of a target while on the other side a TV sweep-actuated reading beam generates readout video. The video is applied to the CRT by a gated amplifier at the same time that an interlacer is applying the TV sweep waveforms to the CRT deflection system. Thus during this interval a 312.5-line field of a televised PPI display is presented.

Symbol video, TV waveforms are gated off

During the same interval of 1/60 sec, symbol video and symbol TV waveforms are gated off. In the next 1/30 sec, the scan-converted TV is gated off, while 12 multiplexed symbol TV waveforms and tracking

more on page 150

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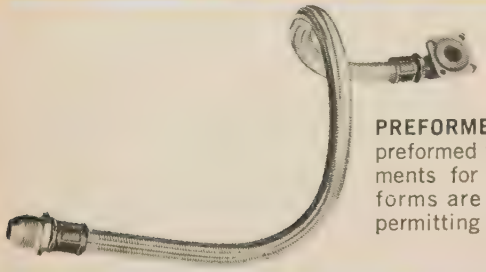

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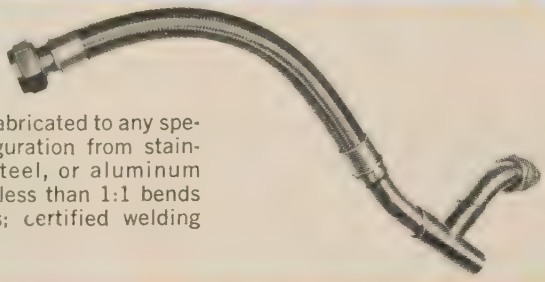

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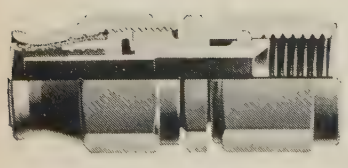

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tags are presented successively near the scan-converted radar targets. The alternate 312.5-line scan-converted TV field is displayed during the next 1/60 sec, after which the 12 remaining tracking tags appear. In this way, the system neglects two-thirds of the normal scan-converted TV fields in order to provide time for the presentation of 24 tracking tags.

If the normal PPI display is to be compatible with the scan-converted one, no symbols can be presented on the normal PPI while radar video is being presented on the scan-converted display. As a result, the field flicker rate of the scan-converted radar picture is only 20 cps, as against the conventional 60 cps.

To cut flicker, kinescopes with P12 screens are used. Though the P12 phosphor can present TV at a 20-cps rate without objectionable flicker, its luminous efficiency is still far less than that of P4 phosphors, and the full brightness capability of the scan-conversion process is not exploited. Nevertheless, at comparable levels of ambient illumination, the scan-converted-symbol compares quite favorably with the radar-symbol display.—End

Sub Detection

Detection of submerged submarines by radar is being looked into by several companies including Arma, GE, and Raytheon for Naval Research Labs. Most of this work is classified.

As no electromagnetic "window" has yet been found in water, the radar would seem to have to depend on detecting some disturbance the submerged sub makes on the surface layer. The radar is believed to operate up in the Q-band (36-46 kmc).

Whether a radar can actually detect submerged subs is a highly controversial point among many research groups. Tests to date, though apparently inconclusive, have been promising enough to make researchers want to continue with them.

Two airborne magnetometers for submarine detection that are being studied by the Navy's BuWeps have sensitivities of about 0.01 gamma, (or 10^{-7} oersteds). Both are electron resonance types—one uses alkali vapor; the other, metastable helium.

If they prove suitable, BuWeps would like to use these instruments in airborne magnetic anomaly detecting (MAD) equipment. It is now using a magnetometer that is a saturable-core magnet with a sensitivity of about 0.1 gamma.

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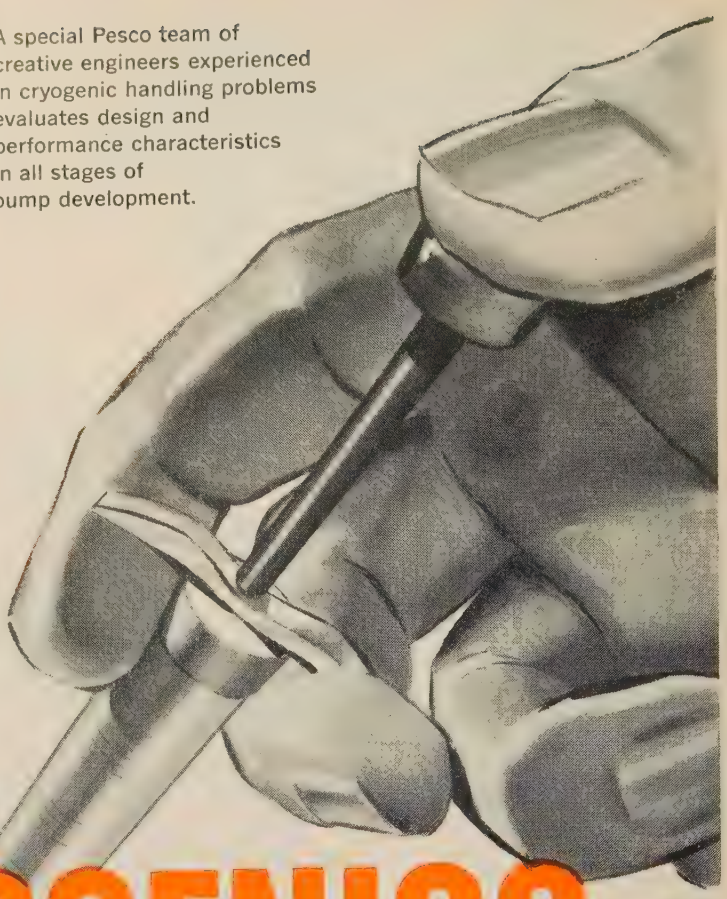

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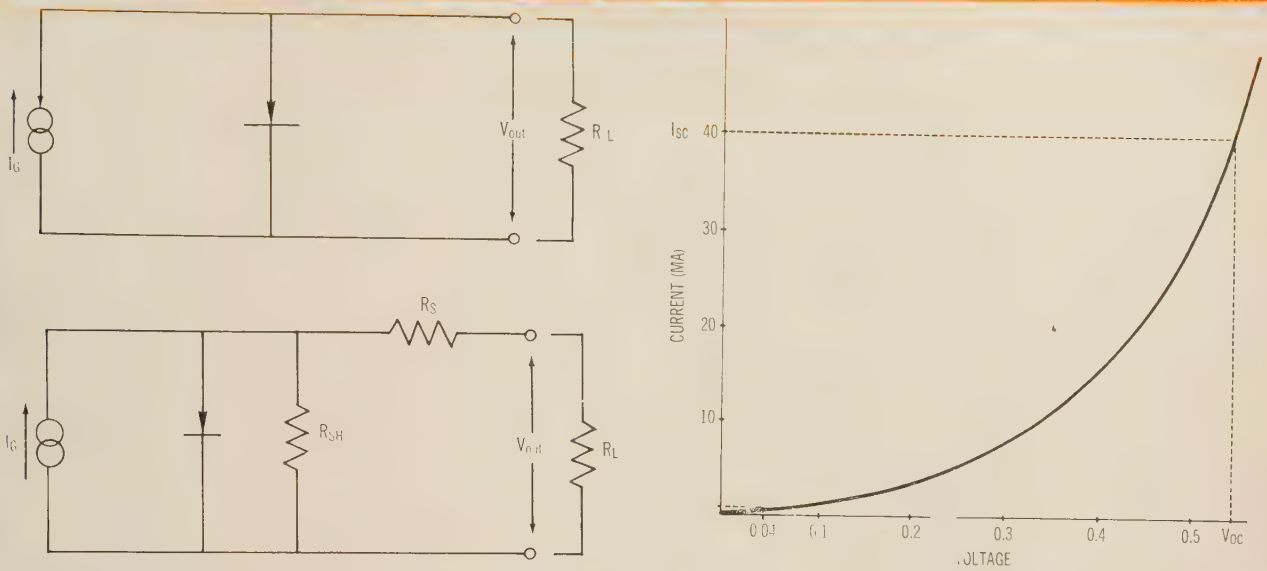

FIGURE 1: Equivalent circuit of a solar cell generator (top left), where I_G is the generator current and R'_L the combined value of the series and load resistances, and a more detailed circuit (bottom left), where R_{SH} is a shunt resistance and R_L the load. Right: A typical diode curve, where I_{SC} is the short-circuit current and V_{OC} is the open-circuit voltage. The curve is assumed to be independent of the light intensity.

Finding the optimum load for solar cells

The success of solar cells in our earth satellites has assured the future of these devices as space vehicle power sources. Designers therefore will welcome this report on a simple, graphic method of finding the optimum load resistance of solar cells.

by A. J. Heager and T. R. Nisbet,
Design Engineers, Missile Systems Div., Lockheed Aircraft Corp.*

THE solar cell can be represented by a current generator in parallel with a forward-biased diode. The current that is generated is proportional to the intensity of illumination. The available power is drawn from terminals basically in parallel with the diode (*Fig. 1*).

Figure 1 also shows a typical diode curve (for simplicity's sake, the curve is assumed to be independent of the light intensity). When the cell is short-circuited through a resistance of about one ohm and subjected to sufficient illumination to cause 40 ma to flow in the resistor, the voltage across the diode will be 0.04 V. At this voltage, the diode current is extremely small and the 40 ma can be taken quite accurately as a measure of the source or generator current for this intensity of illumination.

If the cell is open-circuited under the same intensity of illumination, the entire generator current will flow across the junction. The point I_{SC}-V_{OC} must therefore fall on the voltage current characteristic of the diode (*Fig. 1*).

To find the optimum load, you

more on next page

* Missile Systems Div., Lockheed Aircraft Corp., Sunnyvale, Calif.

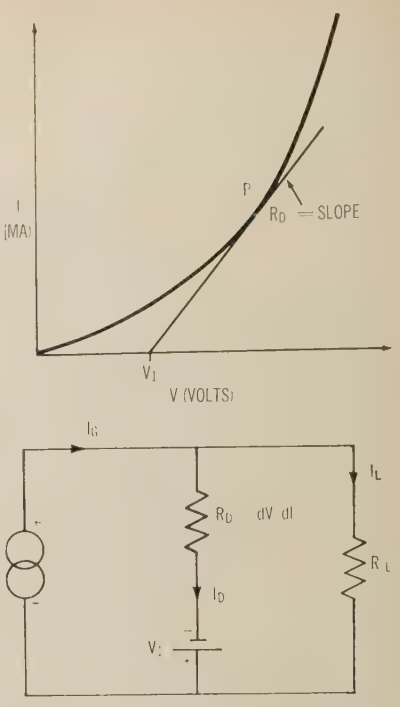

FIGURE 4: An elemental portion of the diode curve and the equivalent circuit over this range.

can consider the series resistance (*Fig. 1*) as part of the load resistance. (When the power in the load resistance is at a maximum, so will be the power in any part of the load resistance.) With this in mind, we'll use R'_L to refer to the combined value of $R_L + R_S$.

Curve equation varies from cell to cell

If the equation of the diode curve were known, the optimum load could be computed. However, this equation varies somewhat from cell to cell and so lends itself more to a graphical solution based on the diode curve.

If an elemental portion of the diode characteristic is considered at point *P*, the curve can be regarded as a straight line of slope dI/dV at *P* (*Fig. 2*). The optimum load resistance over this small range can be found from the equations of the system:

(1) $I_G = I_D + I_L$,
(2) $V_1 + I_L + R'_L - I_D R_D = O$,

where $R_D = dV/dI$ at operating point *P*. By expressing I_L as a function of R'_L and deriving an expression for the power in the load, we get:

more on page 158

Whether an interval is a month or a microsecond, you can measure it, divide it, record it, or use it for control with an A. W. Haydon Company custom-designed or standard timer. Every type, every size, every class...timing motors, time delay relays, interval timers, repeat cycle timers...you name it, we make it. If you ever have a specific timing problem, the least you can do for yourself is get our literature. In fact, why not send for our Bulletin on the 14100 Series DC Motor (above) right now. This two-ounce sub-miniature DC Timing Motor is less than 1" in diameter, 1⅜" long. Used to drive a miniature tape recorder in the Vanguard II weather satellite (expected to remain in orbit for 200 years), it represents the high capability of The A. W. Haydon Company in timing devices.

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Photo courtesy Rocketdyne, a division of North American Aviation, Inc.

Left: Consolidated unit shown at far left provides complete programming and control versatility over wide ranges of test conditions.

Right: CSC's new MicroSADIC high speed analog-to-digital data processor which is the heart of an instrumentation system capable of delivering data from transducers to computer.

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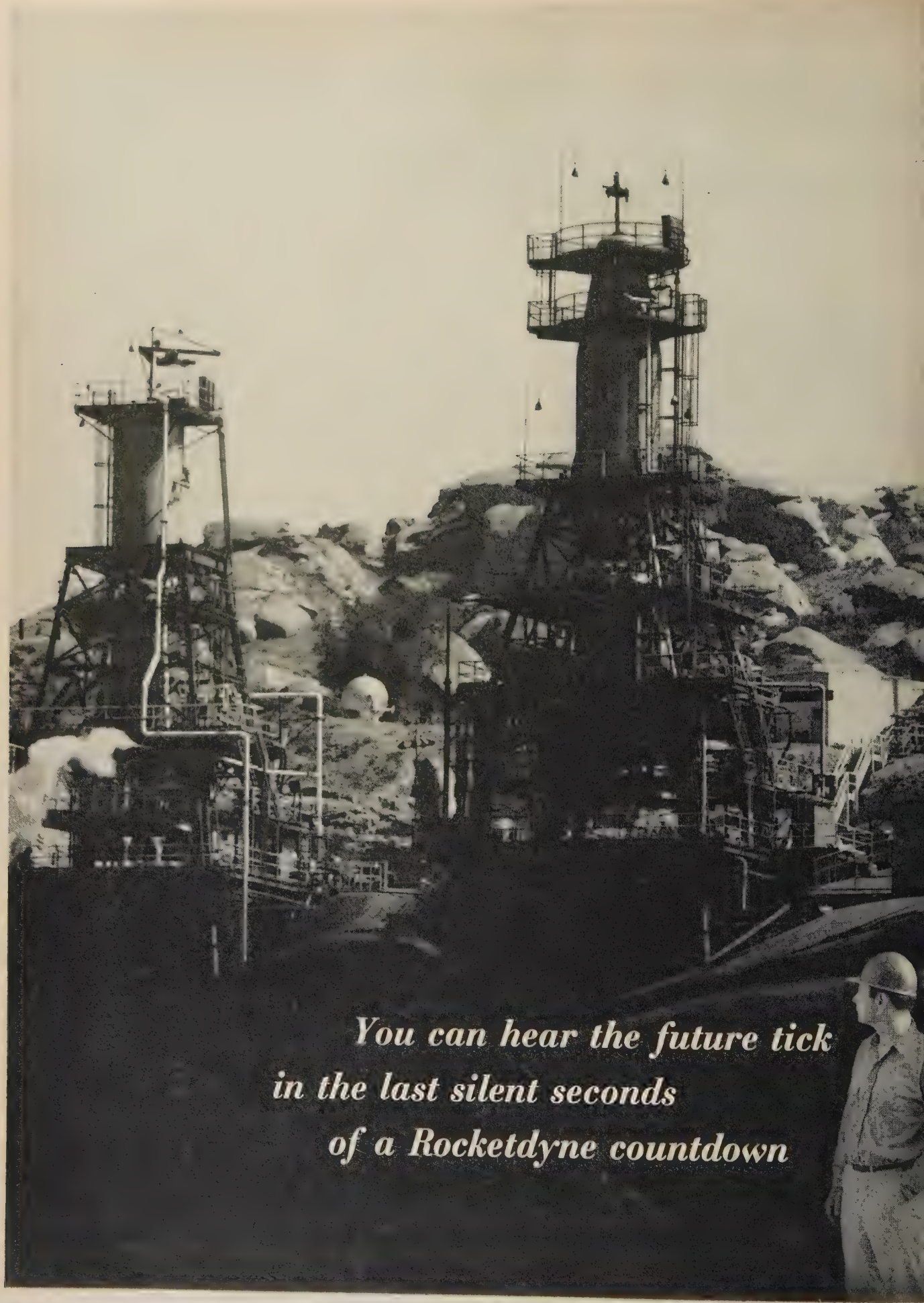
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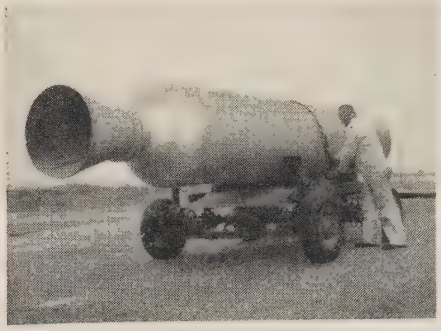

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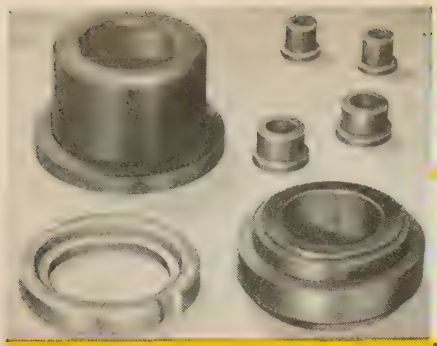

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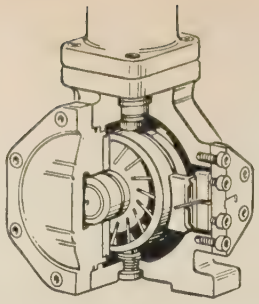

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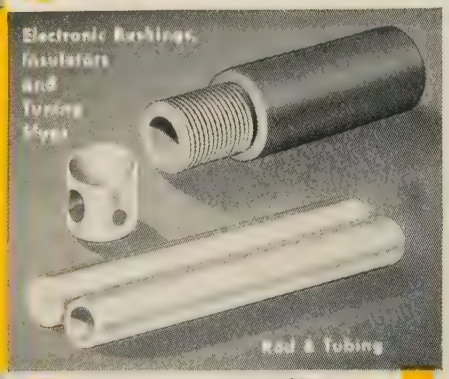

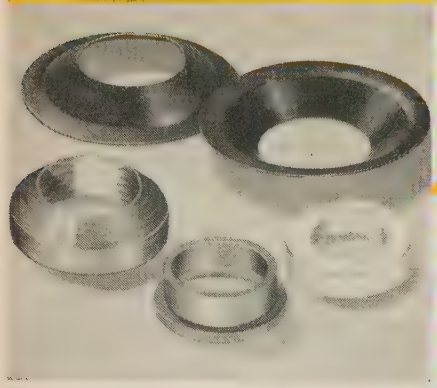

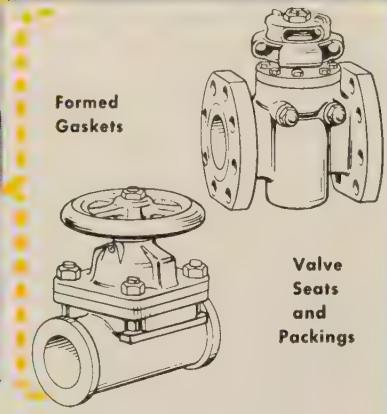

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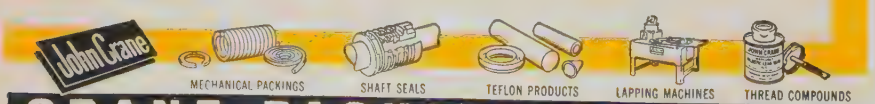

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(3) $P=[(I_G R_D - V_1)/(R_D+R'_L)]^2 R'_L$.
From this we then get:
(4) $dP_L/dR_L=[(R_D+R'_L)^2(I_G R_D - V_1) - R'_L(I_G R_D - V_1)^2\ 2(R_D+R'_L)]/(R_D+R'_L)^4$.
By equating this expression to zero, we find the condition for maximum power in the load:
(5) $R_D = R'_L$.

Figures 3 & 4 show a graphical method of determining the optimum load for a given intensity of illumination. For a fixed value of load resistance, the voltage across and the current through the load have a linear relationship.

In *Figure 3*, *OB* represents the source or generator current. The electric effects in the load are described fully by the rectangle *ABCD*, where *AC* is the slope of the load resistance; *D* falls on the diode curve; *AB* is the current through the load; *AD* is the voltage across the load (which is equal to the voltage across the diode, since the load includes the series resistance R_S); and *OA* represents the diode current.

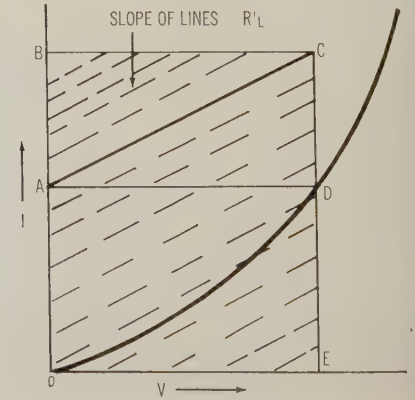
Only one operating point on the diode curve

For a given load and intensity of illumination, there is only one operating point on the diode curve. The load resistance is at an optimum (i.e., the power in the load is at a maximum) when the slope of the diode curve at the operating point is equal to that of the load resistance.

Practically speaking, you can use a six-step method to determine the optimum load resistance for a given intensity of illumination and a given diode curve (*Fig. 4*):

more on page 160

FIGURE 5: Diode curve and the electric effects of a load.



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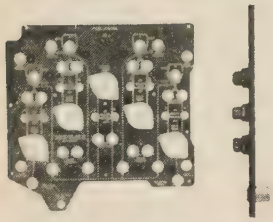

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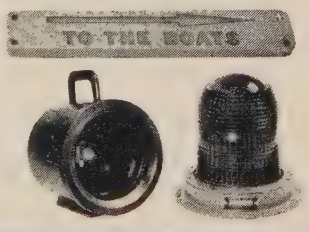

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(1) Take any point P on the knee of the diode curve.

(2) Draw a straight line RP to represent the slope of the diode curve at P.

(3) Find Q as the Y-coordinate of P and draw QS parallel to RP.

(4) Find T as the X-coordinate of P and extend TP to intersect with QS in S.

(5) Find the Y-coordinate of S and compare its value with the short circuit current of the cell (I_{SC}).

(6) Repeat from step 2 on with a new value of P until ST represents the same value of current as I_{SC}. Subject to allowance for R_S in series with R_L (*Fig. 1*), you know that:

- the optimum load resistance is represented by the slope of QS;
- the voltage across the optimum load is OT;
- the current through the optimum load is PS;
- the current through the diode is PT, or OQ;
- the power in the load is represented by the rectangle $QPSI_{SC}$;
- the power lost in the diode is represented by the rectangle $OTPQ$;
- the electric efficiency equals PS/TS times 100 per cent.

Optimum loads vary with light intensity

Clearly a different value of optimum load exists for each different intensity of illumination. If you omit the construction lines of *Figure 4* and simply relate the optimum operating point to I_{SC} (i.e., to the intensity of illumination as in *Figure 5*), you can see that the value of the optimum load increases as the intensity of illumination decreases.

From our analysis, we can conclude:

- *for any cell and a given intensity of illumination,* (1) there is only one operating point on the diode characteristic for each value of load resistance and (2) for the optimum load the slope of load resistance equals that of the diode curve at the operating point;
- *for any cell and a fixed value of load resistance,* (1) there is only one operating point for each intensity of illumination and (2) the optimum intensity is that which requires an operating point at which the slope of the diode curve equals that of the load resistance;

more on page 162

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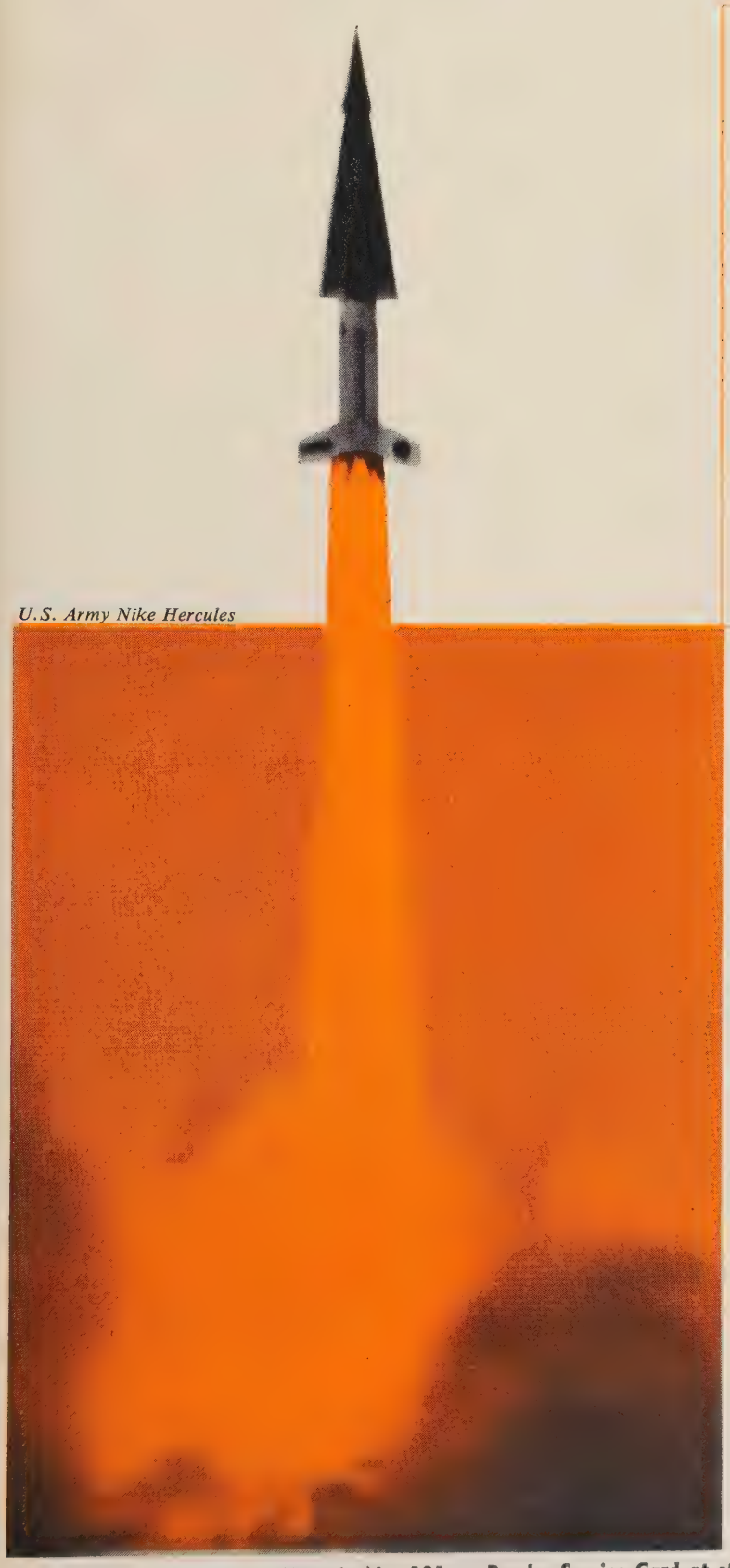

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This unretouched photograph shows the high reflective finish of a Librascope† integrator disc, 1⅜" diameter, made from Kennametal. Little discs like this one are of big importance in the operation of guidance systems, automatic pilots, and gyrostabilizers. In addition to a high polish, the discs must have high YME, hardness, and compressive strength . . . all qualities of Kennametal. Need for these properties, or a combination of other exceptional characteristics, is often met by a specific grade in the Kennametal family of tungsten carbide alloys.

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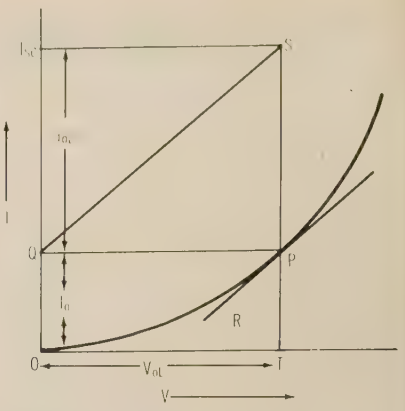

FIGURE 6: Graphic method of finding the optimum load for a given intensity of illumination and a given diode curve.

- *For any cell,* (1) the optimum load resistance increases as the intensity of illumination decreases, and (2) the difference in optimum load vs intensity of illumination with other cells depends on the shape of the diode curve;
- *In any process involving the matching of cells and load resistances,* the shape of the diode curve over the appropriate range of intensities is the decisive parameter to be considered. (Certain conditions, including environmental ones, may modify this shape.)

Effect of variation in light intensity

Consider now the effect of varying the intensity of the light falling on the cell, important because all applications of solar cells involve an intensity that changes with time. For example, a cell fixed on the earth's surface receives an intensity that varies with time according to:

$$I = I_Z \cos \omega t, \tag{6}$$

where I_Z is the intensity when the sun is at the zenith and ω equals $2\pi/T$, with T approximately equal to 12 hours (the night-time period being neglected).

Other examples are easily found, the most obvious being a cell fixed on the surface of a satellite. In this case the motion generally is more complicated, since the satellite may tumble as well as spin. Nevertheless, since the intensity varies as the cosine of the angle, an intensity variation occurs that has the general form of *Equation 6*—only with I_Z no longer a constant but differing for individual revolutions.

Since the intensity changes with time, the time integral of the output

more on page 166

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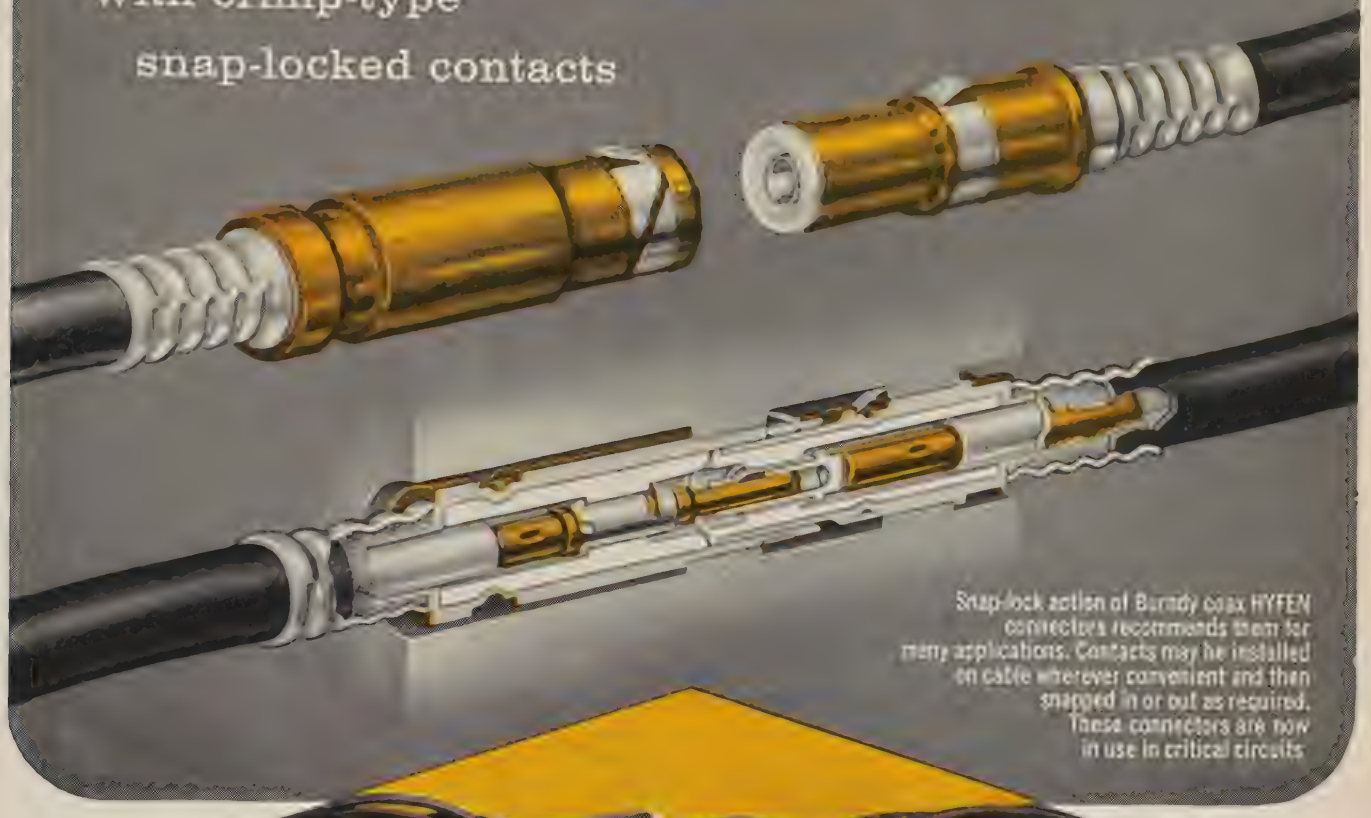
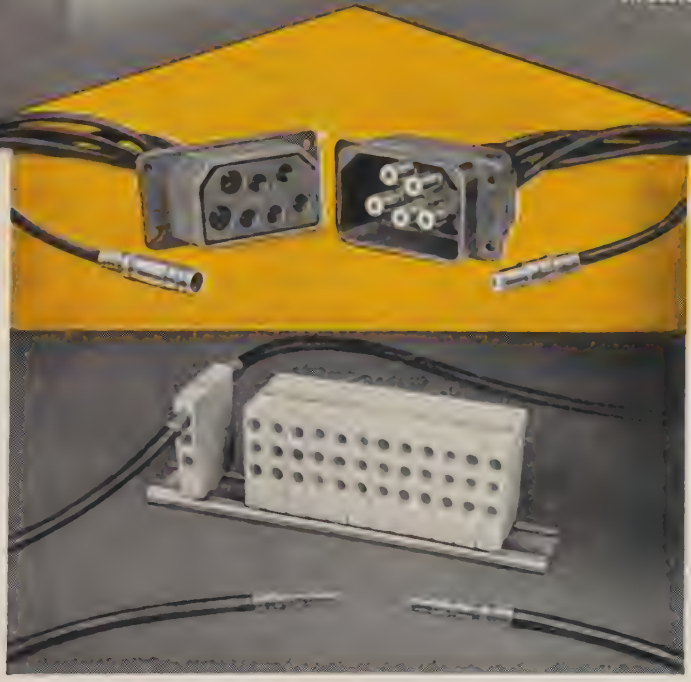
with crimp-type
snap-locked contacts



Snap-lock action of Burndy coax HYFEN connectors recommends them for many applications. Contacts may be installed on cable wherever convenient and then snapped in or out as required. These connectors are now in use in critical circuits

ME7X
...Rack-and-panel Coax HYFEN with one-piece die-cast shell and one-piece block. Mates with existing solder types.

COAX MODULOK
...Modular terminal block. Modules snap together or apart and are mounted on cadmium-plated steel track.



CONNECT QUICKLY
...high speed tooling for volume production results in low installed costs.

CONNECT EASILY
...snap-lock action and simple design with few parts make installation easy – tool crimps contacts in any circumferential position.

CONNECT RELIABLY
...tool-controlled crimp provides strain relief for conductors, guarantees a uniform indent for measurable quality control. There is no heat to damage insulation.

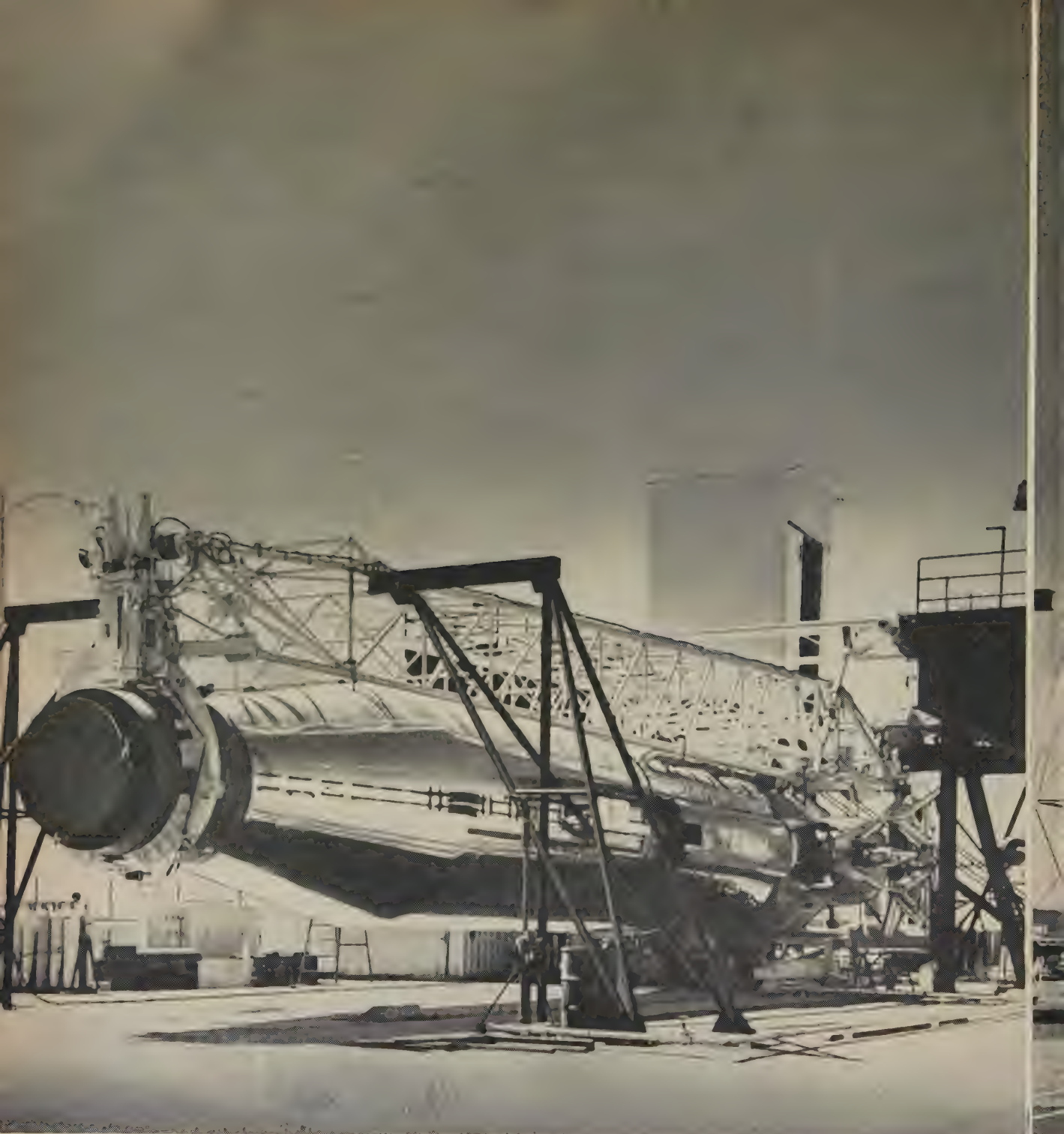
FOR OTHER REQUIREMENTS OR APPLICATIONS, CONTACT **OMATON DIVISION**

BURNDY

59 7

Norwalk, Connect. In Europe: Antwerp, Belgium Toronto, Canada

Write in No. 103 on Reader Service Card at start of Product Preview Section



Westinghouse ATLAS erector control

A single button is pressed . . . prefiring checkout starts and the smooth, programmed rise to firing position begins for the mighty Convair ATLAS.*

The Westinghouse React-O-Verse control system automatically raises the missile to its vertical firing position, checks to make sure that the missile is firmly seated on the launching pad, retracts and rotates the nose clamp and moves the erector boom out of the way—all without flexing or straining the bird at any point in the arc. A very complex and demanding job for electromechanical control.

This precision control, which compensates automatically for varying loads or wind pressures from any direction, is achieved with an exclusive Westinghouse system combining maximum reliability with watch-like accuracy. Static controllers, saturable reactors and Cypak® (miniaturized magamp) units program, check position and release, or, at any malfunction, return the missile to its horizontal position. No moving parts are present to corrode, wear

system assures handling reliability

out, require maintenance or fail at a vital instant.

Whatever your requirements for ground support equipment drive systems—erectors, launchers, shelters, loaders—or shockproof equipment for hardened sites, take advantage of the Westinghouse engineering knowledge, range of products and unit responsibility for any type of electromechanical system. Contact your Westinghouse sales engineer or write: Westinghouse Electric Corporation, 3 Gateway Center, P. O. Box 868, Pittsburgh 30, Pa.

**The new ATLAS erector system is supplied by Goodyear Aircraft Corporation, Arizona Division, Litchfield Park, Arizona, under contract to Convair Astronautics Division, San Diego, California, prime contractor to USAF for ATLAS.*

J-92039

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Westinghouse

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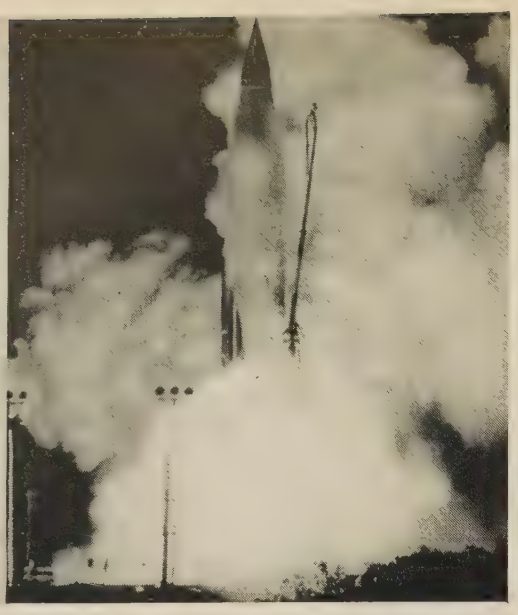
ON EVERY ATLAS COUNTDOWN

PRESSURE GAUGES ARE CONSULTED

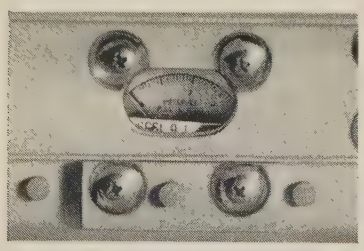


Used for Readout of Gas Pre-Charge in Hydraulic System Accumulators

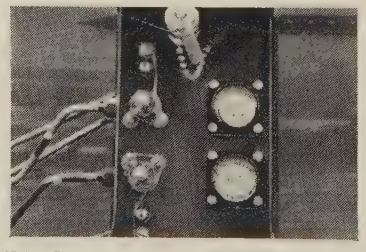
Complete reliability, freedom from jamming even under severe overloads, resistance to shock and vibration, the ability to keep functioning accurately whether setting in the desert sun or subjected to extreme cold . . . these are some of the reasons you will find 6 RMC-Lindsay High Pressure Gauges on each Convair Atlas.

These gauges must withstand shock tests of 100Gs. They are checked for accuracy in vibration tests ranging from 10 to 2,000cps at 35Gs and at ambient temperatures from −65°F to +275°F. *There is no linkage, no gear train to disintegrate or to cause pointer vibration. The indicating pointer is attached directly to the end of the helical bourdon coil.*

RMC Gauges are built to the most exacting laboratory standards for accurate performance under the most rigorous conditions encountered in modern industry, in jet aviation, in astronautics.



RMC Gauge for the booster engine hydraulic system accumulator is flush mounted on the booster engine compartment for easy reading from the outside.



RMC gauges used on sustainer of engine hydraulic system are mounted on the side of the missile fuel tank beneath a maintenance access panel.

If you have a high pressure gauge problem let RMC engineers work with you in its solution. Write, wire or phone:

ROCHESTER MFG. CO. OF CALIFORNIA
1401-B S. Shamrock Avenue, Monrovia, California

ROCHESTER MANUFACTURING CO., INC.
224 Rockwood Street, Rochester 10, N. Y.

RMC
LINDSAY PRESSURE GAUGES

NEW RMC PLANT IN MONROVIA

The new RMC Monrovia, California plant has been specifically designed for full scale plant production of precision instruments without sacrificing laboratory production standards.

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power is important rather than the power at any particular instant. We can expect, therefore that the proper load for maximum work over a period of time during which when the intensity is changing will be different from the proper load for maximum work over the same period while the intensity is constant.

Generator current varies with illumination

The generator current of a cell is found experimentally and theoretically to be proportional to the intensity of illumination. If the illumination is given by *Equation 6*, the generator current then has the form *(Fig. 1)*:

(7) $I_G = I_{G(O)} \cos \omega t.$

From the equivalent circuit, you can see that:

(8) $I_L = I_G - I_o(e^{\lambda V_L} - 1),$

where I_L is the load current; I_G the generator current; I_o, the reverse diode current; V_L, the load voltage, or voltage across the diode; and λ equals e/akt, with e being the electronic charge; t, the absolute temperature, and a a constant greater than 1. Substituting the explicit form of I_G, we get:

(9) $I_L = I_{G(O)} \cos \omega t - I_o(e^{\lambda G V_L} - 1).$

The power delivered to R'_L is therefore:

(10) $P_L = V_L[I_{G(O)} \cos \omega t - I_o(e^{\lambda V_L} - 1)].$

Reverting now to *Equation 9*, we can write:

(11) $V_L = (1/\lambda) \ln [(I_G - I)/I_o].$

From the form of this equation, it is clear that the load voltage changes very slowly with the incident intensity: $I_G - I_L$ itself changes slowly, and only its logarithm enters into the equation. In fact, it has been found experimentally that the voltage changes by less than three per cent as the intensity varies from full sunlight to about 10 per cent of full sunlight. Therefore, we can approximate the voltage as a function of intensity with a step function:

(12) $V_L(I) = \begin{cases} O & \text{intensity} = O \\ V & \text{intensity} \neq O. \end{cases}$

With this approximation, you can find the effect of the varying intensity on the optimum load voltage. The average power output over a half-period is:

(13) $P_{av} = 2/T \int_{-T/4}^{T/4} V_L[I_{G(O)} \cos \omega t - I_o(e^{\lambda V_L} - 1)]dt.$

Since V is constant in the step func-

more on page 168

Up to 5 megohms in a ½-watt resistor . . .
and better operating
characteristics, too!

Only the WESTON VAMISTOR®

offers performance like this!

Here, at last, is a precision metal film resistor which offers substantial advantages over all other types—wire wound, deposited film, etc. Look at this list of VAMISTOR capabilities and characteristics:

- VAMISTOR HANDLES HIGHER WATTAGES. Up to 8 full watts at 40 C for Model 9849-2.
- VAMISTOR OFFERS HIGHEST RESISTANCE RANGES. For example, 1.5 megohms in ¼-watt size . . . 5 megohms, ½-watt.
- VAMISTOR HAS OUSTANDING THERMAL CHARACTERISTICS. Runs cooler . . . resists thermal shock. Standard temperature coefficient doesn't exceed 50 ppm/°C.—lower than Nichrome wire. Also available with maximum of 25 ppm/°C. Temperature coefficients don't vary over the resistance range.
- VAMISTOR OFFERS UNUSUALLY LONG SHELF LIFE, STABILITY. Exclusive process of fusing element to inside of steatite tube assures long life, improved resistance to all environmental conditions.
- VAMISTOR IS MORE RELIABLE; HAS GREATER MEAN-TIME-TO-FAILURE.
- VAMISTOR PRODUCES NO CORONA; IS AS NOISE-FREE AS BEST WIRE-WOUND RESISTORS.
- VAMISTOR OFFERS EXCEPTIONAL PERFORMANCE UNDER RADIATION.
- VAMISTOR ACCOMMODATES HIGHER MAXIMUM CONTINUOUS WORKING VOLTAGES.
- VAMISTOR IS VIRTUALLY NON-INDUCTIVE. Capacitance characteristics are superior to all other existing resistors.
- VAMISTOR IS SUBJECTED TO STRICTER QUALITY CONTROL THAN ANY OTHER RESISTORS.
- THE VAMISTOR LINE CONFORMS TO MIL-R 10509C CHAR. C. Styles RN-65, RN-70, RN-75 and RN-80.

For full information, contact your local Weston representative . . . or write to Daystrom-Weston Sales Division, Newark 12, N. J. *In Canada: Daystrom Ltd., 840 Caledonia Rd., Toronto 19, Ont. Export: Daystrom Int'l., 100 Empire St., Newark 12, N. J.*

MIL STYLE	WESTON MODEL	WESTON DIMENSIONS	
		LENGTH	DIAMETER
RN-65, RI-92	9855-2	0.650	0.235
RN-70, RI-94	9852	0.866	0.312
RN-75, RI-96	9850-2	1.120	0.411
RN-80	9849-2	2.156	0.411

WESTON Instruments

A DAYSTROM UNIT

WORLD LEADER IN MEASUREMENT AND CONTROL

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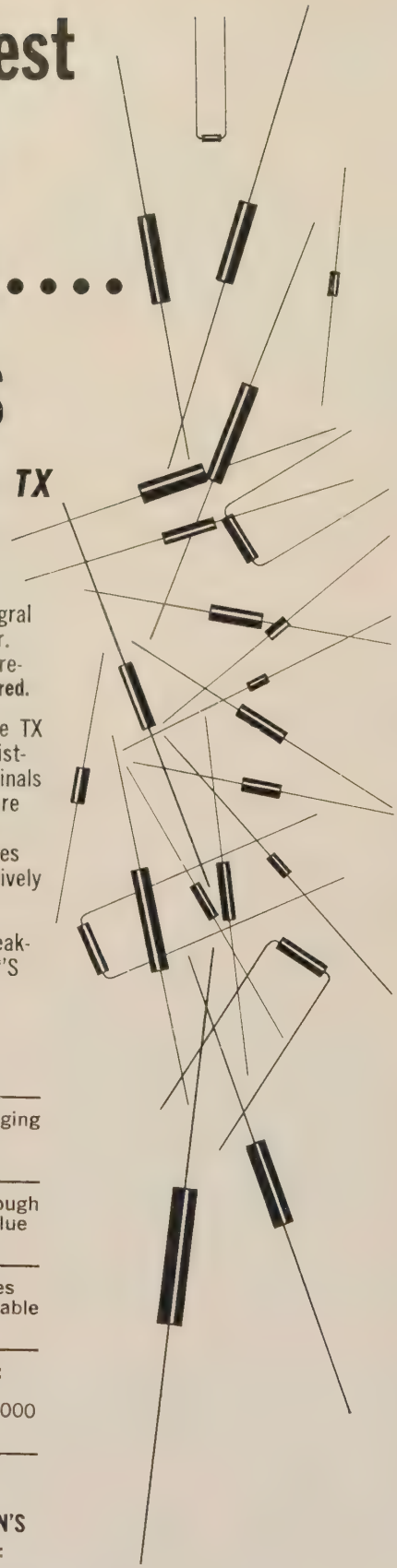
The Strongest Links In Your Circuits....

PRECISION'S

Sub-Miniature Type TX

Wire Wound Resistors



True uniformity of performance is an integral part of every PRECISION Type TX Resistor. Whatever physical size or resistance value resistor you use, unswerving **reliability is assured.**

According to your need, PRECISION'S Type TX Resistors may be had in the size and resistance value you want for your circuit. Terminals may be either axial or radial. Tolerances are standard from ±1% to ±1/20%. Where extreme accuracies are required, tolerances to ±1/100% may be obtained . . . inductively or non-inductively wound.

Dangerous "cross-overs" and insulation breakdowns have been eliminated by PRECISION'S winding method . . . another reason why Military requirements are to PRECISION'S specifications.

PHYSICAL SIZE: Available in 75 sizes, ranging from diameters from 3/32" through 3/8" and lengths from 3/16" to 1½".

RESISTANCE RANGES: From .01 ohm through 5.0 megohm — in any resistance value required or decimal part thereof.

ACCURACY: ±5% to ±1/20%. Tolerances ±1/50% to ±1/100% (absolute) available on specification.

TEMPERATURE COEFF. OF RESISTANCE: Standard ±0.001%°C. throughout. Special temperature coefficient + 5000 ppm° to ±1 ppm°C.

For complete information about **PRECISION'S Sub-Miniature Type TX** Resistors, write to:

PRECISION RESISTOR Co., Inc.

MANUFACTURERS OF WIRE WOUND RESISTORS EXCLUSIVELY

115 U. S. Highway #22, Hillside, New Jersey

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tion approximation, the $VI_{G(0)}$ term can be brought out of the integral sign:

(14) $P_{av} = V[(2/\pi)I_{G(0)} - I_o(e^{\lambda V_L} - 1)]$.

If the intensity had remained constant at $I_{G(0)}$ throughout, then the expression analogous to *Equation 14* would be:

(15) $P_{const} = V[I_{G(0)} - I_o(e^{\lambda V} - 1)]$.

For maximum power:

(16) $(dP/dV)_{Vmp} = O = (2/\pi)I_{G(0)} - I_o(e^{\lambda V_{mp}} - 1)\lambda I_o V_{mp} e^{\lambda V_{mp}}$,

where V_{mp} is the voltage for maximum power, or:

(17) $e^{\lambda V_{mp}} = (2/\pi)[I_{G(0)}/I_o(1 + \lambda V_{mp})], e^{\lambda V_{mp}} \gg 1$.

The analogous expression for constant intensity is given by:

(18) $e^{\lambda V_{mp}} \approx I_{G(0)}/I_o(1 + \lambda V_{mp})$.

The solutions are easy to compare graphically

The solutions of *Equations 17 & 18* are easily compared graphically *(Fig. 6)*. We now see that the optimum voltage for the cosine intensity (V_1) is less than the optimum voltage for the constant intensity (V_2).

To find the effect of the varying intensity on the optimum load resistance, we must refer to the diode curve of the cell *(Fig. 7)*. Since V_1 is less than V_2, it is obviously desirable to operate at P_2 when the intensity is constant and at P_1 when it varies sinusoidally. We have already seen that the slope of the diode curve at the operating point determines the optimum load resistance. In fact, we can write:

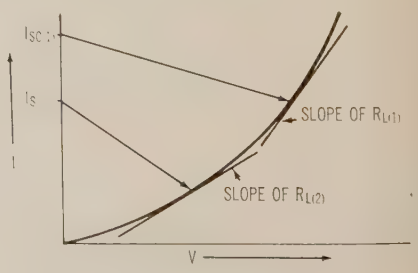
(19) $R_{opt} = (dV/dI)a + V = V_{mp}$.

Since dV/dI is less at P_2 than at P_1, we may conclude that the optimum load resistance for incident light of varying voltage will not be the same as that which gives the maximum power at constant intensity—it will be somewhat larger in ohmic value.

Obviously the optimum load re-

more on page 172

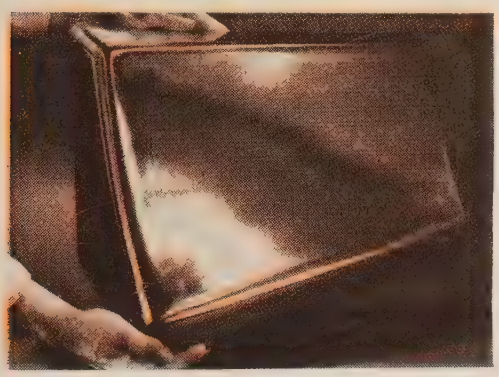
FIGURE 7: Operating point in relation to I_{sc}.



Heat Repulsed Here

Lightweight Silicone Laminates Withstand Continuous 750 F

Ducts, pods, heat-shields, electronic components and other high-temperature parts for missiles or aircraft can be fabricated easily of lightweight silicone laminates. These laminates have good strength, good heat resistance, and are unaffected by moisture, weathering, ozone and corrosion, thermal shock or fungus attack. Dow Corning silicone resins, coupled with glass cloth or other inorganic fillers, give better strength-to-weight ratios "at temperature" than many light metals. And they're simple to form.

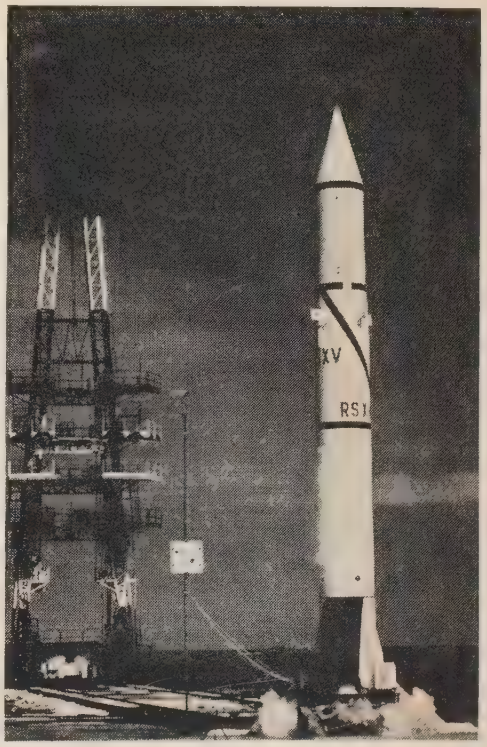


In the North American Aviation Super Sabre F-100, for example, designers needed a rigid material for the drag-chute case. As this chute case fits right up against the engine at the rudder base, the rigid outer wall of it must: 1) reflect heat away from the chute; 2) resist jet engine ambients; 3) retain structural strength without necessity of replacement.

Development engineers tried numerous "high-temperature" plastics without success. Too much heat. Then they hit on silicone-glass laminate, gold-metallized for heat reflectance. Not only did this prove entirely suitable, it also turned out to be more easily formed. The finished part can endure continuous service at 750 F and intermittent exposure to 1200 F. Vibration resistance is excellent.

Silicones for the Army Redstone

In the Redstone, Chrysler Missile Division engineers employ silicone laminates several ways. As in the case of the F-100, large heat shields behind the Redstone's engine compartment are fabricated of the laminates because of their light weight, heat resistance, thermal impedance. Also, due to excellent electric strength and creep resistance, silicone laminates are utilized for terminal boards in black boxes within the missile and in Ground Support Equipment control boxes.



For further data and a list of fabricators of silicone laminates, write today to Dept. 0724

first in silicones

Dow Corning CORPORATION
MIDLAND, MICHIGAN

ATLANTA BOSTON CHICAGO CLEVELAND DALLAS LOS ANGELES NEW YORK WASHINGTON, D. C.

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HOT GAS SYSTEM COMPONENTS NOW AVAILABLE FROM CHANDLER EVANS

CECO SYSTEMS CONTROLS

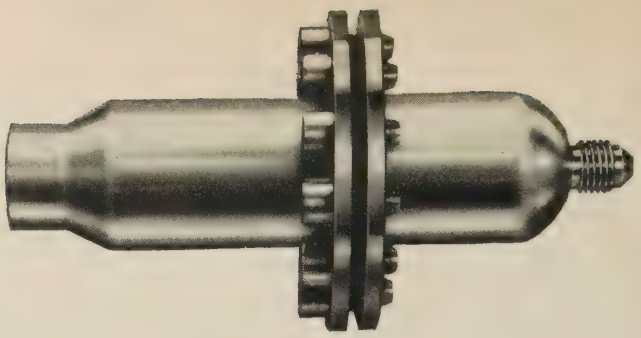
As by-products of extensive development work in the field of high-pressure pneumatics, Chandler Evans has—over the past several years—designed, developed, tested and produced a number of hot gas servo system components, some of which are presented here.

The products shown and described were developed for use with high-pressure hot gas generated from liquid or solid propellants, and are suitable to such applications as auxiliary and control power systems for guided missiles and space vehicles.

All the components shown are developed items, ready for use. However, because they have been fabricated to meet the requirements of particular applications, the specifications presented should be considered only representative. Design modifications can readily be made to adapt these devices to *your* requirements.

If you, too, are engaged in hot gas systems work and want to save considerable time and money in development, by using proven components not heretofore available, CECO will be happy to afford you its traditional cooperation.

For detailed information on these and other components, or for data on CECO's hot gas servo *systems*, contact any of the Field Engineering Offices listed at the right.

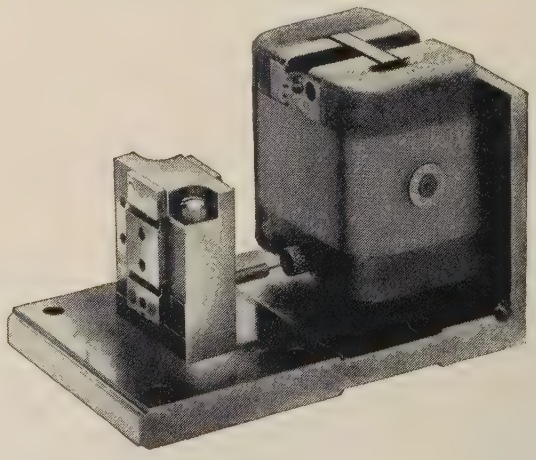


LIGHTWEIGHT HYDRAZINE REACTION CHAMBER

This reaction chamber, containing a suitable catalyst bed and injection nozzle, is used to generate hot gas. When hydrazine from a pressurized source is introduced, the catalyst immediately initiates a chemical reaction which continues until the fuel supply is exhausted.

Representative specification:

Operating temperature	to 1800°F.
Operating pressure	to 2000 psi
Flow capacity	.10 lb./sec.
Operating time	in excess of 5 hrs.
Weight (including catalyst)	1.27 lbs.
Size	1.50″ O.D. x 5.00″



REED-SUSPENDED, CLOSED CENTER SERVO VALVE

Developed for use with hot gas produced by decomposition of liquid propellants, the servo valve shown here is currently available in a variety of sizes to accommodate the requirements of individual applications.

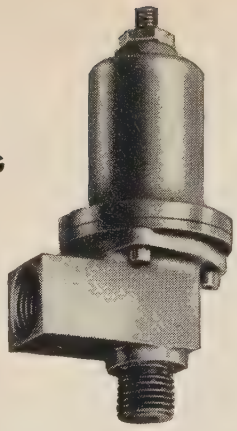
Representative specification:

Inlet gas supply pressure	to 2000 psi
Inlet gas supply temperature	to 1500°F.
Operating temperature (ambient)	to 350°F.*
Valve stroke	±.004″
Flow capacity (total gas flow)	.01 lb./sec. air @ 1500°F., 2000 psi
Overboard leakage (valve at null position)	10% of total flow
Power input (maximum)	2 watts
Natural frequency	430 cps
Weight	1.00 lb.
Size	1.75″ x 2.75″ x 1.75″

** With additional torque-motor cooling, ambients to 1200°F. can be tolerated.*

CHANDLER EVANS CORPORATION

PROPELLANT FLOW MODULATING AND PRESSURE REGULATING VALVE



The problem of operating hot gas generators at a specified constant pressure level led to the design, test and development of the liquid fuel regulating valve pictured here.

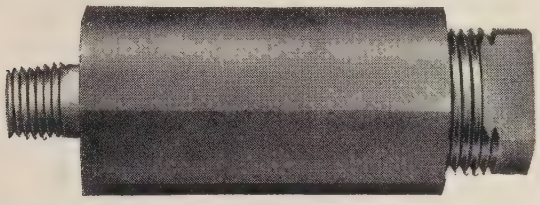
This valve may be described as a spring-loaded, spool-type throttling valve. Full open when the pressure at its outlet port (gas generator pressure) is low, it progressively closes off as the outlet pressure increases.

With minimum leakage an important objective, the valve shown meets the following specification:

Flow (hydrazine)	.002 to .02 lb./sec.
Upstream pressure	500 to 3000 psi
Regulated pressure	500 to 2000 psi
Temperature	0° to 200°F.
Weight	.38 lb.
Size	1.75″ O.D. x 3.00″

Limited changes in regulated pressure can readily be accomplished by means of a simple adjustment screw. Broader changes in regulated pressure or in flow capacity can be accomplished through slight re-design of the spool or spring elements.

SOLID PROPELLANT HOT GAS FILTER

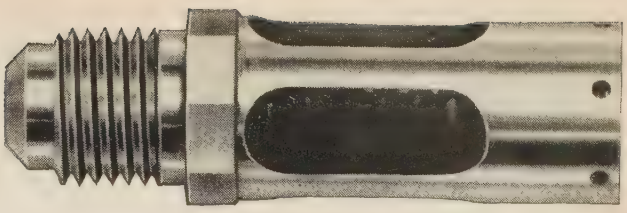


Since small-orifice areas of servo valves cannot tolerate contaminants produced by combustion of solid propellants, CECO found it necessary to develop the special hot gas filter shown here. Unlike those heretofore available, this filter can easily be cleaned for re-use and has amply demonstrated its ability to withstand the temperatures and pressures encountered in hot gas systems.

It operates as follows: hot gas flows into an annulus between the filter element and housing, then diffuses through to the outer surface of the element, depositing solid particles as it goes. With gas flow at .015 lb./sec., this filter operates for several minutes, with average contamination, filtering out particles as fine as 10 microns.

Representative specification:

Operating temperature	to 1800°F.
Operating pressure	to 2000 psi
Initial pressure drop at .015 lb./sec.	2 psi @ 1000 psi
Filter housing size	1.38 O.D.″ x 5.00″
Weight	.88 lb.

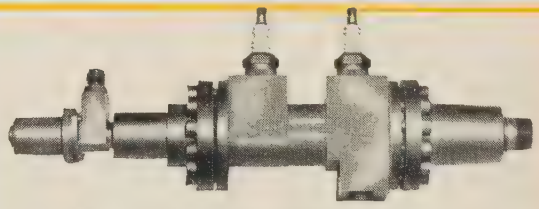


HOT GAS PRESSURE RELIEF VALVE

Typical of component hardware developed by CECO in its work with hot gas servo actuation and reaction systems is the valve pictured here. While it can easily be modified to satisfy other requirements, specification for the valve shown is as follows:

Relief pressure	1000 psi*
Reseat pressure	950 psi
Flow	.02 lb./sec. @ 1000 psi
Temperature	1800°F.
Weight	.032 lb.

** Adjustable from 800 to 1200 psi.*



HOT GAS REACTION CHAMBER FOR LABORATORY USE

This unit is used as a "workhorse" hydrazine reaction chamber to provide clean, hot, high-pressure gas for test purposes.

Ideal for laboratory use, its flow rates range between .001 and .1 lb. sec., and may be extended in either direction by changing nozzle and load orifice sizes. Operating temperatures are between 1200°F. and 1800°F. with pressures to 2000 psi.

The chamber is preheated by an electrical coil, a feature which facilitates repetitive starting without need for disassembly between test runs to renew the catalyst.

The above picture shows CECO's generator with the pressure regulating and flow modulating valve in position. For those who require a complete, "packaged" system for providing a continuous supply of hot gas, Chandler Evans can supply a complete laboratory model hot gas generator system including the fuel storage, pressurizing, purging and pressure regulating elements in addition to the gas generator reaction chamber described above.

CECO® SYSTEMS CONTROLS

CECO FIELD ENGINEERING OFFICES:

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CHANDLER EVANS CORPORATION

Literature, including a reprint of this ad, available by request to Department 69.

CHANDLER EVANS CORPORATION

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STAINLESS STEEL TUBING

Pressures demanded by missile, rocket and supersonic aircraft hydraulic and pneumatic systems of current military specifications are emphatically resisted by dependable PATCO stainless steel tubing.

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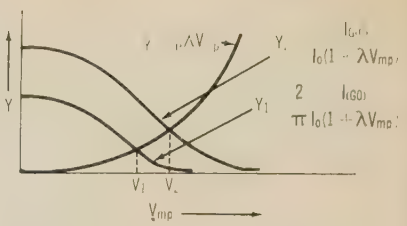

FIGURE 8: Graphic comparison of solutions of Equations 18 & 19.

sistance depends very largely on the conditions of a cell's particular application. As an example, take the case of a satellite carrying six cells placed symmetrically on its surface and tumbling and spinning randomly. Over a period of time, all the cells receive the same average illumination, but at any instant there are one or two cells that are more brightly illuminated than the others.

The optimum load resistance in this case is different depending how the cells are connected:

- If the cells are connected so that each is always in use no matter what its illumination (e.g., each is connected to a separate heater as the load), then the integration should be over a full half-period (180 deg) just as in the example we have studied and the effective operating point should be chosen as P_1 in *Figure 7*.
- If the cells are connected through diodes so that only the one most brightly illuminated is in use, then the integration should be over a shorter range (from 90 deg for six cells to 30 deg for 12 cells if the tumbling and spinning is random and long periods of time are considered). The effective operating point *(P)* in this case should be chosen so that $P_1 < P < P_2$, where P_1 and P_2 are as in *Figure 7*.

The speed of tumbling and/or spinning has no effect on the choice of optimum load, for the integration is over a period or some fraction thereof and the time always cancels.

We can see that the optimum load depends on *two* distinct aspects of application:

- It depends on how the intensity varies on a cell and on whether or not the cell is used together with a sun-seeker.
- It depends on how the cell is connected electrically — in other words, over what portion of its "il-

more on page 174

Where can you use this versatile HI-SHOCK SWITCH?

Military missiles, mines, shipboard antennas, or industrial and commercial equipment wherever rigorous vibration, shock or constant acceleration is present, this new Hi-Shock Switch offers distinct advantages.

Engineered and custom-packaged. The Hi-Shock Switch can be used for remote power switching (mounted directly on moving members)... changeover from primary to auxiliary power source, AC or DC... rapid stepping of power distribution.

Hermetically Sealed. Use in remotely controlled, power operated units or as a sequence exciter for auxiliary prime movers.

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Other models also developed with varying configurations and contact arrangements with higher current rating. Write for complete details. *Hi-Shock, Singer Military Products Division, Singer-Bridgeport, 915 Pembroke Street, Bridgeport 8, Conn.* 1999

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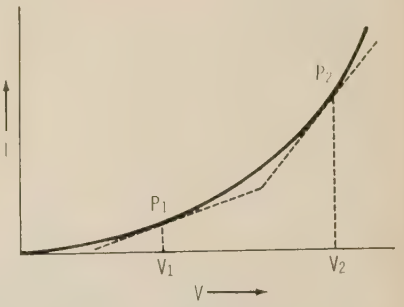


FIGURE 7: Effect of varying intensity on optimum load. It is desirable to operate at P_2 when intensity is constant and at P_1 when it varies sinusoidally.

lumination period" the cell will be active in supplying power to its load.

This evaluation of the application of course again shows the usefulness and importance of the diode curve of the cell. In the end, it is always the diode curve that determines the optimum load resistance.—End

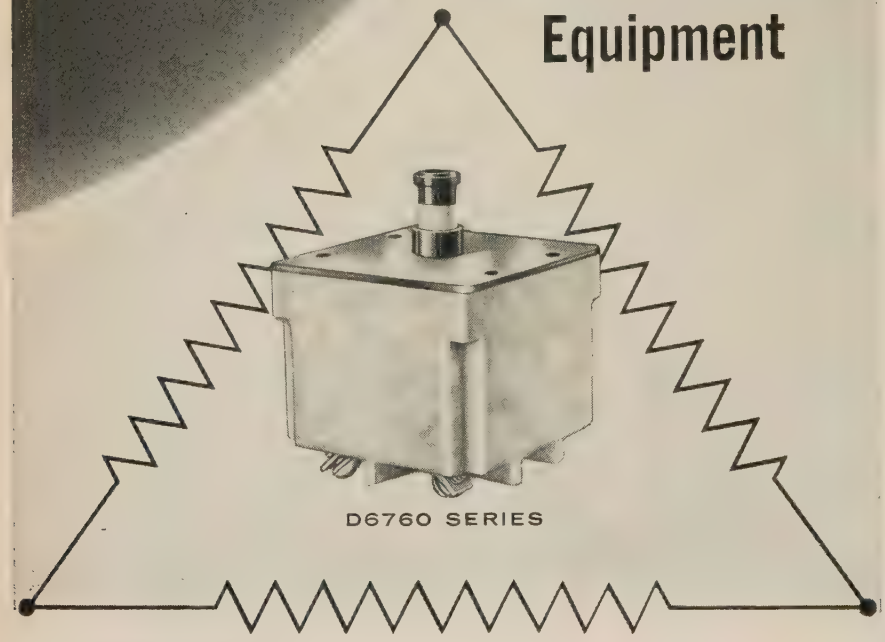
Loctracs for ATC

Latest answer for our air traffic control problem, suggested by Lockheed's Electronics & Avionics Div., calls for blanketing the country with a three-dimensional electronic "checkerboard" (with squares measuring ⅛-1 mile per side). The system would tell sector controllers just what square an aircraft is in and give the plane's identification and height.

Loctracs (*Loc*kheed *Tr*acking *a*nd *c*ontrol *s*ystem) is based on automatic and continuous transmission of coded signals from small, light transmitters carried in all aircraft. Every transmitter would be on the same frequency in the line-of-sight range. The transmitters would operate in conjunction with a ground net of four receivers for each Loctracs sector (a rectangular area measuring 70-100 miles per side). Altitude coverage would be 1200-100,000 ft.

According to Lockheed, each Loctracs sector could observe and distinguish more than 1000 aircraft at a time. The system would make it possible to predict congestions and near-collisions far enough in advance to warn the pilots concerned, Lockheed disclosed.

NEW KLIXON
Three-Phase
CIRCUIT BREAKERS
...for Aircraft and Ground Support Equipment



Advantages:

- Simultaneous tripping of all three phases with overload in one or more circuits . . . assures positive circuit protection.
- Single button opens or recloses all three phases.
- Quick trip . . . 2 to 6 milliseconds on short circuit interruption.
- Shock resistance 25G's.
- Thermal type . . . weight approximately 8 oz.

The KLIXON D6760 series three-phase circuit breakers are especially designed to handle extremely high AC short circuits. Variations of the D6760 are available providing—larger reset button to facilitate manual operation (-1 model) . . . greater electrical clearances between phases for short circuit interruption of 800 to 1000 amperes at 440 volts (-5 model) . . . with a two-pole construction for aircraft AC electrical systems (-6 model) . . . different ampere ratings in each phase to break three loads of different current values simultaneously (-7 model). They are available in ratings from 5 to 60 amperes. Minimum AC rupture capacity 2500 amps, 1 ϕ, 120 VAC, 400 cps.

Write for specification data which gives complete details.

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And—because it must not fail, Hazeltine engineers specified A-MP Solderless Taper Pins and matching Blocks for all critical circuits. A-MP Taper Technique gives Hazeltine the uniform top reliability and compact size it demands as well as great versatility: formed or pre-insulated solid taper pins in three series; wide size range of stackable one- or two-piece blocks plus precision crimping tools. Everything is solderless, of course.

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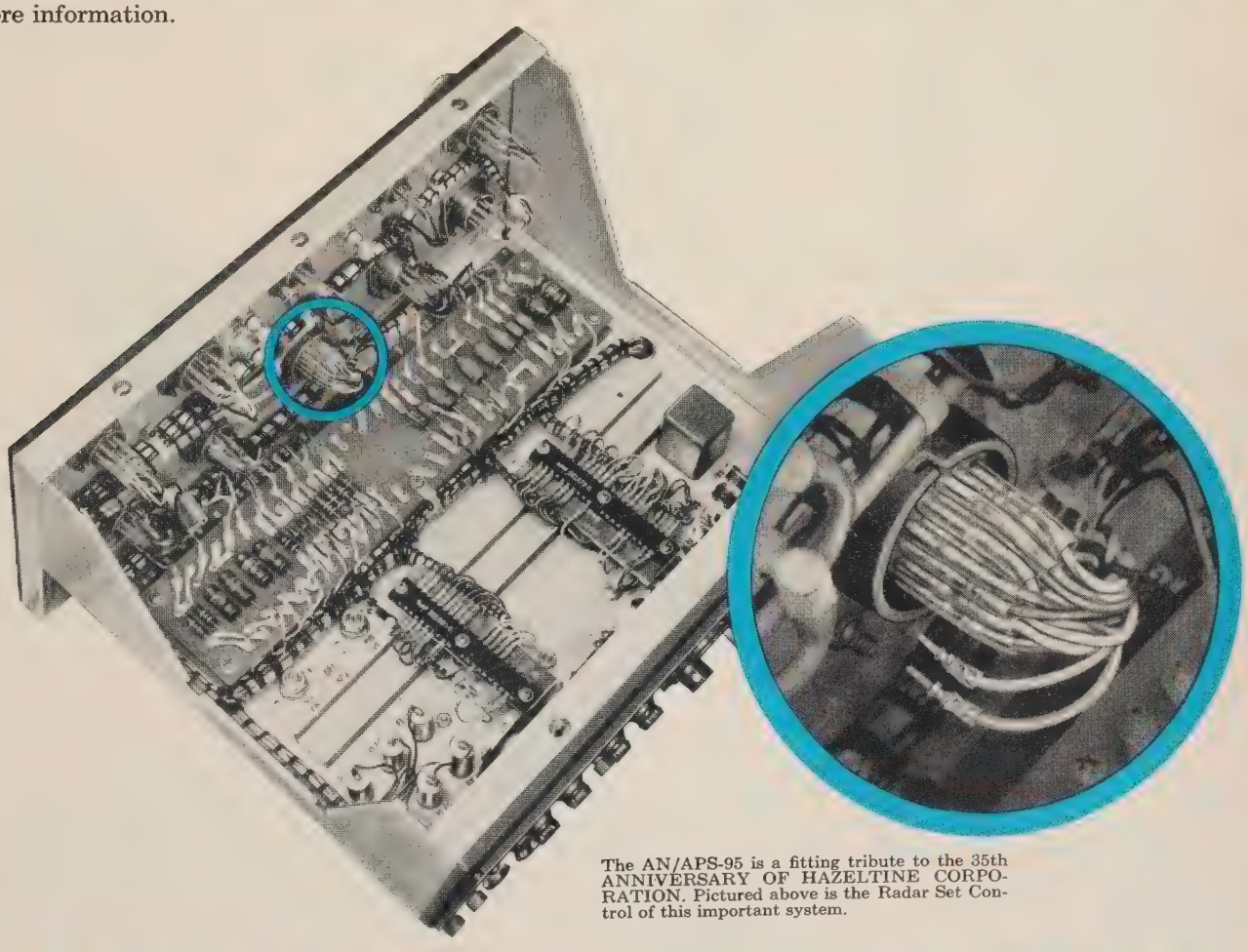

The AN/APS-95 is a fitting tribute to the 35th ANNIVERSARY OF HAZELTINE CORPORATION. Pictured above is the Radar Set Control of this important system.

AMP INCORPORATED

GENERAL OFFICES: HARRISBURG, PENNSYLVANIA

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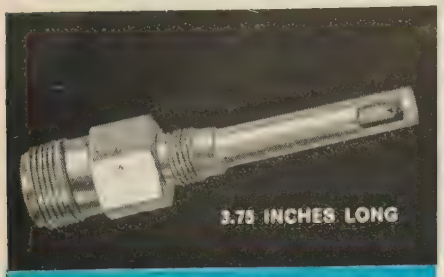
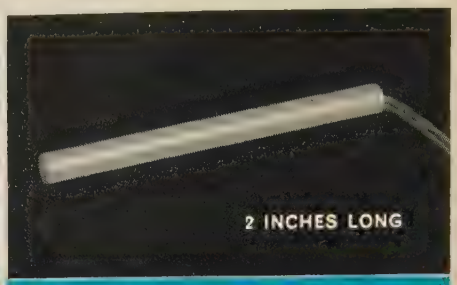


Duct type thermostat. For duct gas or fluid sensing applications. Employs the latest in unique stainless steel brazing techniques for high temperature and high pressure applications. (This type thermostat being used by Douglas Aircraft Company for ground support cooling equipment—in conjunction with VĀP-AIR panel for Hi and Lo temperature warning system —for the Thor Missile.)

Surface type thermostat. For surface "area contact" temperature sensing. Employs the latest in high heat resistant materials for adequate ambient temperature isolation and excellent shock and vibration characteristics. (Used by Northrop Corporation for controlling critical mass temperature in a sub-miniature accelerometer.)



Well type thermostat. Cylindrical shape —suitable for "blind" well applications for sensing case temperatures. (This type thermostat being used by Sperry Gyroscope Company to sense and control accelerometer housing temperature.)

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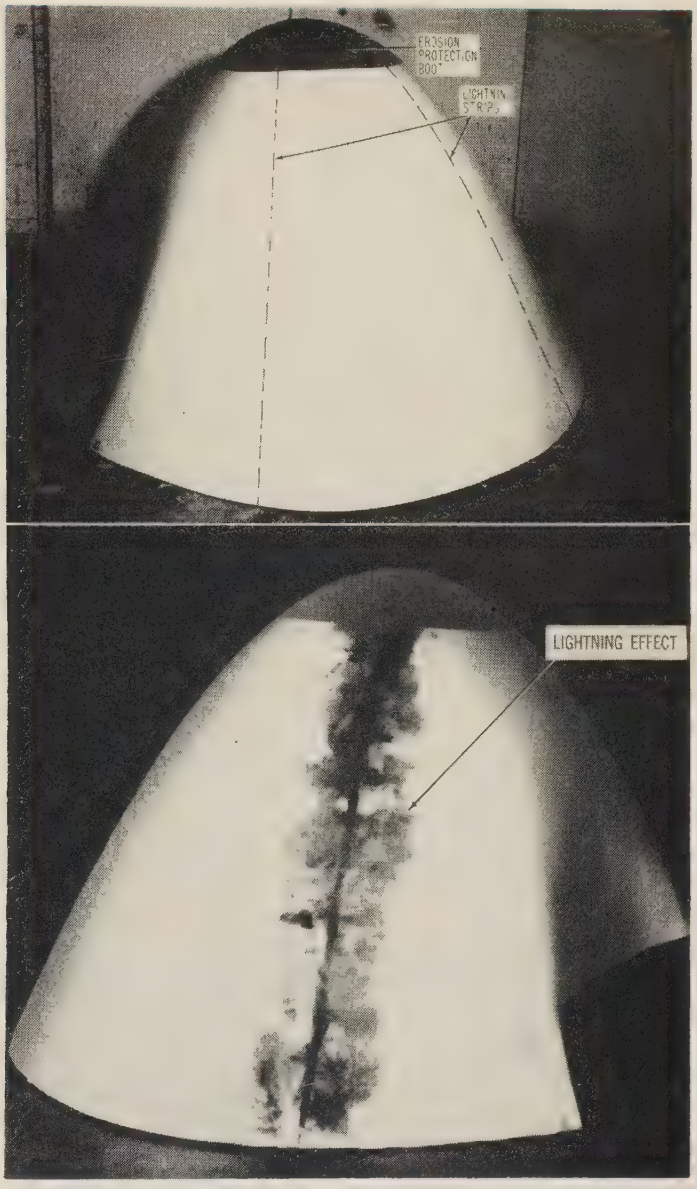
How to protect radomes from lightning



On the large, high-speed jets, lightning damage to the radome could become a big problem. Here's a way of taming the bolts and still preserve the original antenna pattern.

by M. P. Amason,
Radiation Systems Engineer, Transport Div., Douglas Aircraft Co.*

FIGURE 1: Final radome before and after lightning test. After exposure to a lightning stroke (right), the radome shows only a smudged region that was easily wiped clean—there was no damage to the radome.

THE larger radomes used on the latest big multi-engine jets are quite susceptible to lightning damage—enough so that they could easily turn the annoying maintenance problem posed by lightning strokes into an operational hazard. Within an eye to safeguarding its new DC-8, Douglas therefore undertook the development of a light, simple, and inexpensive lightning protection system for general-purpose weather radar radomes.

The high-voltage phase of our development program was run at the Lightning & Transients Research Institute (LTRI), on Minneapolis, Minn. To establish areas of varying vulnerability, a series of tests was first run on a 1/50-scale model of the Douglas DC-6B. Using LTRI's high voltage, low current generator, we subjected the model to a large number of artificial strikes from several different directions.

The number of hits on different areas of the plane was tabulated and compared with data from in-flight service records. Close correlation between experimental results and service records proved the correctness of

more on next page

* Transport Div., Douglas Aircraft Corp., Santa Monica, Calif. This article describes a proprietary development of Douglas Aircraft. License information is available from Douglas on written request.

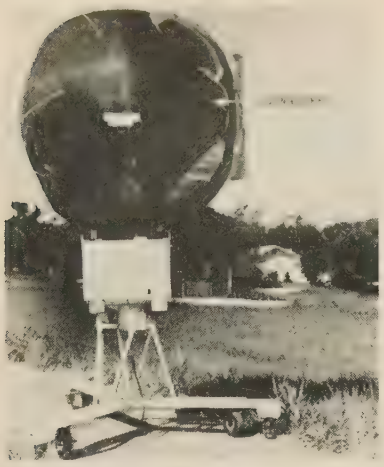


FIGURE 2: Test fixture and radome used to determine effects of different lightning strip configurations on radar attenuation and pattern.

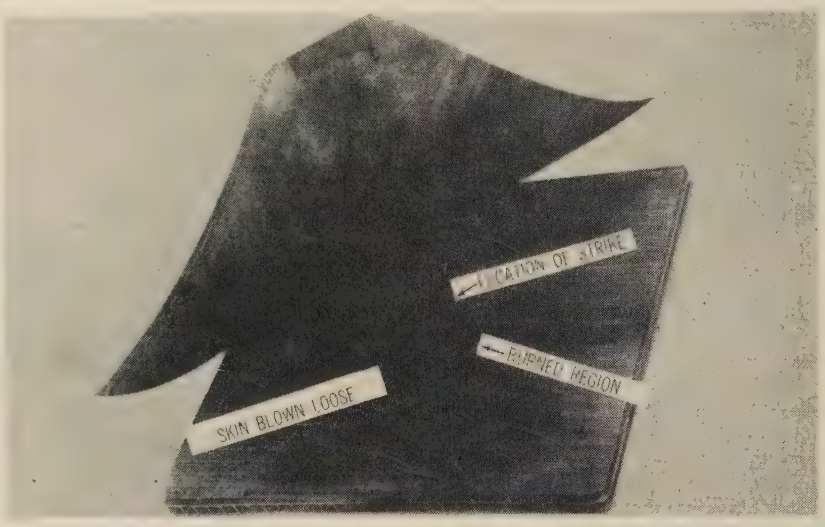
the test procedure, which then was applied to a 1/72-scale model of the DC-8 (*Fig. 5*).

As the test results showed, the nose is quite vulnerable to lightning. Unfortunately, the radome can't very well be installed anywhere else—the radar is, after all, supposed to look forward. Some alternative radome sites are theoretically possible, but they all would involve external pods or large fairings, and these would produce too much aerodynamic drag.

In the next phase of our program, we tested sample plastic parts, each about one square foot in size and built to simulate the radome wall configuration. The combined output of several LTRI generators was used to evaluate the mechanical properties of each part and its resistance to gas blast effects and to burning or melting (*Fig. 3*). The results of these tests clearly showed the need for a lightning protection system.

A full size radome was next

FIGURE 3: Effect of lightning on a one-foot-square panel of unprotected plastic laminate construction.



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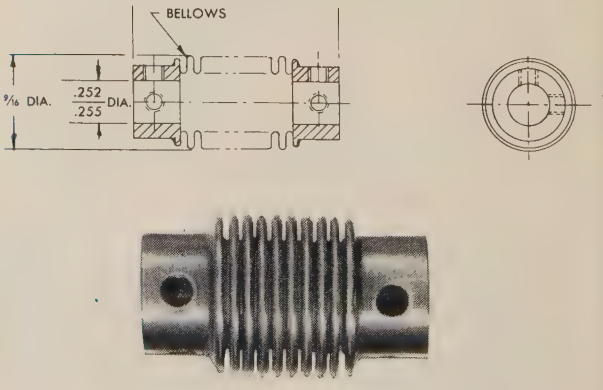


Servomechanisms, instruments and similar drive and control systems are the big users of these small, flexible units. Ideal for guarding against misalignment friction and bearing wear problems. Save space and weight. Cut down noise. Simplified design utilizes seamless metallic bellows, in choice of several metals, connected to two hubs. Sizes from 15/32" O.D. Stock sizes accommodate shafts from 1/8" to 1/2". Other sizes custom-engineered. **WRITE FOR DATA SHEET G8012!**

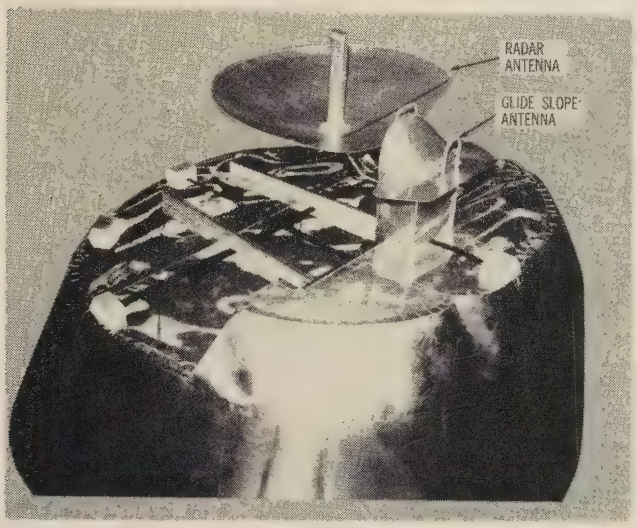
tested in the form of a mock-up of the nose region including the antennas (*Fig. 4*). Tests of a full-scale mockup were necessary because of the peculiar mechanism of lightning-stroke formation near aircraft. When the step leader of a stroke approaches a plane, an intense electric field is set up. Streamers produced by this field rise from high-gradient points on the aircraft to meet the step leader. These points occur in the nose region along the edges of the radar antenna and its mounting structure.

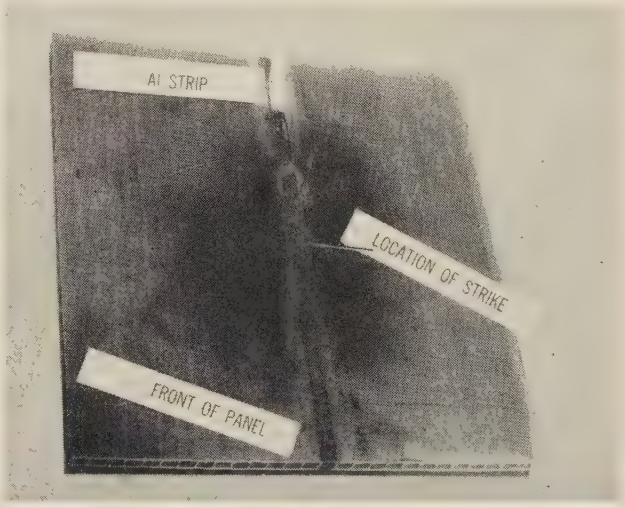
Streamers may start from these edges inside the radome, puncture the radome in several places, and link up with the main stroke. The streamers produce only pinholes, but the main stroke may pass down the streamer, go through the radome, and cause extensive damage (as our parts tests had shown).

To test the dielectric strength and flash-over characteristics of the radome mockup, the entire nose fixture was subjected to a series of 1,500,000-V lightning discharges.

more on next page

FIGURE 4: Full size test mockup of the DC-8 nose section (left) used in the high voltage program at LTRI. Right: Test panel of the type shown in Figure 3 protected by a 3/8-in.-wide lightning strip of 0.003-in. aluminum.





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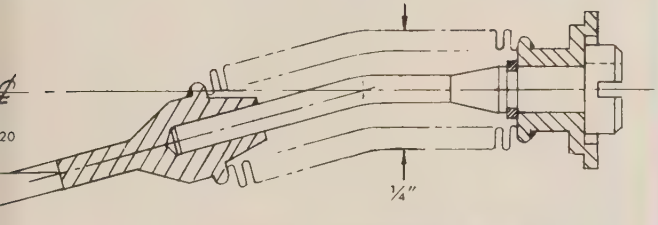

Seamless metallic bellows only ¼" and 5/16" O.D. permit further miniaturization in aircraft, missiles, instruments and other equipment. Available in a wide range of bellows metals to provide the desired strength and performance characteristics. Sensitive to temperature and pressure changes. Custom-engineered . . . but available in any quantity you need. Proved in dozens of miniaturized assemblies. **WRITE FOR BULLETIN G8012!**

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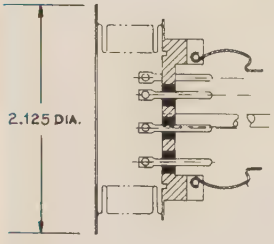

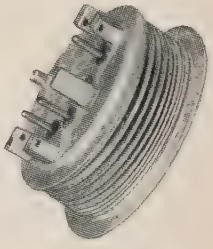

A low spring rate and a large stroke per unit of length, provided by a special Robertshaw Metallic Bellows called Formset, made possible this expansion capsule used in airborne gyroscopes. This assembly absorbs the thermal expansion of the oil which encases the gyroscope. Low spring rate in the bellows permits low pressure in the gyro. Space savings of up to 90% in bellows length can be achieved with Formset Bellows. Custom-engineered for instruments, transformers, relays and other applications using any fluid. **WRITE FOR ENGINEERING DATA SHEET G1012!**

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Other features: With suitable circuitry, outputs of from 0 to 5 volts; ranges of from −320 F to 1000 F; mounting permits variation in tube length —also changing element while fitting is in place; LOX compatible; pressure rating, fluid-immersion, 4500 psi to 1000 F; pressure rating, gas-immersion, 4500 psi at 77 F and 2000 psi at 1200 F; resistance tolerance to 0.5%; and, solder terminals for increased reliability. Bulletin 308.

Arnoux Corporation
11924 W. Washington Blvd. • Los Angeles 66, California

ARNOUX
phonetically, say Are'new
TEMPERATURE TRANSDUCERS

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We wanted to find out whether its dielectric strength would let the radome withstand puncture during the brief interval before external surface flash-over occurs to lower the potential across the radome wall.

In this test, the simulated strikes passed through the radome to the antenna—obviously the glass fiber resin laminates making up the radome wall had low dielectric strength. Earlier tests at LTRI had

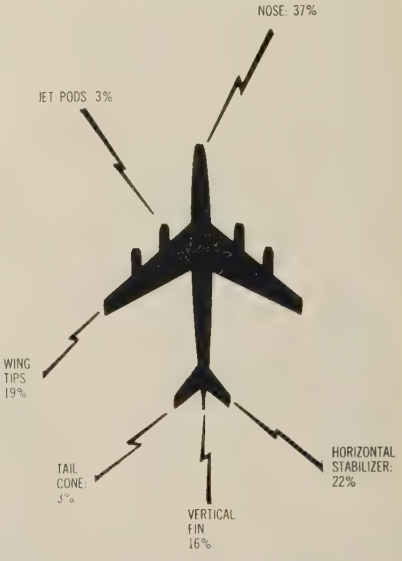


FIGURE 5: Lightning vulnerability of various exposed points on the DC-8. Percentages are of total hits in simulated lightning test on a 1/50-scale model of the Douglas jet.

shown similar poor results for most airborne radomes.

The design of any radome lightning protection system depends largely on the type of radome you are dealing with. On the DC-8, we had to do with a general-purpose radome of the type used with search and weather radars. With this type, neither directional accuracy nor reflection minimums pose serious problems.

A variety of lightning protection systems has been developed for plastic aircraft sections in general.

- *Stroke-guiding systems* are applied on canopy-type enclosures. They use the dielectric strength of materials like the acrylics to withstand puncture for the brief interval before flash-over occurs. Because of their physical and electric properties, the acrylics don't lend themselves to radome contruction.
- *Exposed grounded metal but-*

more on page 184

USE LOTS OF TAPE?

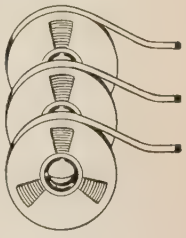
"SCOTCH" BRAND Instrumentation Tapes cut operating costs

Let's develop our own small theory of relativity. For everything's relative, after all—even economy. Clearly, an economy effected now and *corrected* later is no economy at all. In instrumentation tape, there's only one genuine economy—reliable performance. And in performance, the last two words for any acute tape-user are "SCOTCH" BRAND.

First to last, "SCOTCH" BRAND Magnetic Tapes offer uniformity and reliability—born of the experienced 3M technology that created the first practical magnetic tape and continues to advance the art of tape-making day by day.

But let's look at economy from another viewpoint —in terms of some things around the periphery that might not come so readily to mind—storage, use, waste, and time saved.

What other kind of record is so permanent it may last a lifetime, yet requires so little space for storage? Three reels of "SCOTCH" BRAND like those at the right "contain" 30 million characters. What other medium serves input, output and memory functions at such high speeds? Accepts both digital and analogue data?



What other kind of record is not *consumed*, even when it is used? "SCOTCH" BRAND Magnetic Tape is run and rerun for analysis, erased and used again, permits retaping with corrections, editing and new data.

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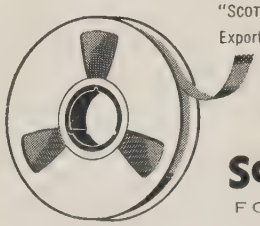

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Important career positions are available at Lockheed Missiles and Space Division at its new facilities on the beautiful San Francisco Peninsula – one of the choicest living areas in the nation. Headquarters for the Division are at Sunnyvale, California, with Research and Development Facilities located in the Stanford Industrial Park in nearby Palo Alto.

The Division is widely diversified—having complete capability in more than 40 areas of science and technology, from concept to operation. Areas of work include: metallurgy; sonics; reconnaissance; computer design and development; propulsion and exotic fuels; space physics; hydrodynamics; the flight sciences; space medicine; manned space vehicles; telemetry; electronics; applied mathematics; operations research and analysis; space communications; reentry; design; and test, both environmental and flight.

Equipment and facilities are completely modern and include one of the largest computer centers in the world.

The Division is systems manager for several major long-range projects and its research and development programs reach far into the future. It is a rewarding future with a company that has an outstanding record of leadership and progress.

Unusual opportunities exist for experienced engineers and scientists to contribute to the solution of new problems in the areas listed on the next page. If you are experienced in these areas, or have background in related fields, we invite your inquiry. Please write: Research and Development Staff, Dept. L-16B, 962 West El Camino Real, Sunnyvale, California. U.S. citizenship required.

AERO AND FLIGHT DYNAMICS AND PERFORMANCE

Advanced degree preferred with background in one or more of the following areas: flight test analysis of reentry trajectories and/or systems evaluation; flight test analysis of trajectories and separation evaluation; theory of subsonic and hypersonic aerodynamics; underwater stability and control hydrodynamics; aerodynamic preliminary design studies; research in gas dynamics studies of thrust vector controls, stage separation, propulsion systems analysis, and rocket nozzle design; or wind tunnel studies and testing.

ANALOG COMPUTING

Advanced degree required with real time experience with analog computers. For the solution of problems in flight controls; guidance; aero and thermo dynamics; dynamic analysis and process controls.

ANTENNA DESIGN

Advanced degree in E.E. preferred with background of several years' experience in antenna design for space vehicles.

CHEMISTRY

Ph.D. preferred, advanced degree required, with strong research background for development work in fuel cells; batteries; the direct conversion of electrochemical energy; electrode kinetics; catalysis; photochemistry; thin film; and solid state. Work concerns both military and commercial applications.

Advanced degree required, Ph.D. preferred with background in either physical-organic chemistry; inorganic chemistry; analytical chemistry; or electrochemistry for research and development work in such areas as: instrumental analytical techniques including infrared, ultraviolet and mass spectroscopy; gas solid reaction kinetics; microchemical analysis techniques; surface treatment of metals and surface reaction kinetics; molecular resistance of substances to various environments including formulation of elastomers; or reinforced plastics.

INFRARED

Advanced degree in E.E. or physics preferred but not required, with experience in infrared systems research and development, or electrical engineers with background in electronics information theory; servomechanisms; specialized circuitry, as in low-level voltage circuits, or physicists with background in optics or semi-conductors. For work in infrared physics research; advanced systems development; or physical measurements in infrared.

TELECOMMUNICATIONS

Degree in E.E. or communications with background in design of UHF, VHF and RF transmitters; telemetry systems and components; circuit design or logical design components.

LOGICAL DESIGN

Background of graduate work in E.E. or math., with interest in advanced areas of computer research in such efforts as: pattern recognition; automata studies; logical design and switching theory; information retrieval; and behavior patterns of artificial neurons patterned closely after those of the human brain.

MECHANICAL DESIGN

Advanced degree in M.E. preferred with background of mechanisms and small structures desirable. For research in experimental design and the development of a variety of research test models.

Advanced degree in M.E. preferred with experience in the design of aero and thermodynamic missile scale models including previous work in wind tunnel model design and test. Shop liaison experience desirable.

METALLURGY

Advanced degree preferred for basic and applied research in one or more of the following areas: metallurgical behavior and mechanisms concerning high temperature and advanced missile materials with interest in metal physics; deformation and fracture; phase equilibria; transformations; or diffusion. Also, to conduct basic and applied studies in refractory metals; dispersed phase systems; fiber metallurgy; ceramics and thermal protective materials systems. Also, for X-ray and electron diffraction research and studies in single crystals; point defects; parameter measurements; pole figure determinations.

MICROWAVE

Experience required in MASER amplifiers and variable reactance parametric devices, for experimental research in microwave.

ORDNANCE

Degree in E.E. required and several years' experience in developmental testing of ordnance and pyrotechnic devices, preferably in the missile field, with complete familiarity with high speed oscillography; pin techniques; pulse circuitry techniques; high speed photography; and instrumentation methods for recording pressure; shock; velocity and temperature for the development of ordnance equipment for missiles.

SOLID STATE DEVICES

Advanced degree required and Ph.D. preferred in E.E., physics or chemistry and evidence of creative, original work through published articles, patents or superior Ph.D. theses for research work in one or more of the following: thermoelectric; photovoltaic; lumistor; ferrite; logic component; sensor; thermistor; or cryogenic devices. Also, materials analysis and evaluation; processing techniques design and development of novel electronics devices and components; circuit analysis; circuit topology; or microminiaturization.

Lockheed / **MISSILES AND SPACE DIVISION**

Systems Manager for Navy POLARIS FBM; DISCOVERER, MIDAS and SAMOS; Army KINGFISHER; Air Force Q-5 and X-7

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RP76 rocket powered target missile manufactured by Radioplane, a division of Northrop Corp.
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Specified by major manufacturers for use in every phase of modern flight, the Iron Fireman family of precision displacement gyros is constantly expanding to meet the ever increasing demands of the aircraft and missile industry. These Iron Fireman gyros have consistently met and exceeded the high standards of accuracy, dependability and performance dictated by the space age.
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Terrier missiles manufactured by CONVAIR, Pomona, a division of General Dynamics.
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tons, though effective when the ground lead is not installed parallel to the inside surface of a low-dielectric material, were not practical for our radome—the moving antenna would have interfered with a non-parallel lead.

- *Stroke-diverting rods* have been proved in laboratory tests to be quite effective for such extremities as the wing and tail tips, but they aren't applicable to the nose.
- On the *graded-resistance system,* more development work is needed on determining the fields of increased resistance to rain erosion and radar transmission loss before this design can be seriously considered.
- *External conductors* are used as a network that forms a shielding cage over the nose area and reduces the tendency toward streamer formation from points inside the radome. The cage also provides points from which external streamers may start and intercepts any main strokes in the vicinity of the radome.

The external-conductor system obviously was best suited to our particular application. Nevertheless, a number of problems remained to be solved. We had to:

- devise suitable metallic conductors and installation methods,
- determine the number of conductors needed for adequate protection and their location.
- establish the configuration of the shielding cage and determine its effect on radar attenuation and pattern.
- determine the effect of the lightning strip on the performance of the glide slope antenna that is also included within DC-8 the radome.

Earlier tests at LTRI had shown that an external conductor with a cross-section of 20,000 circular mils is not seriously damaged when it intercepts a main stroke. However, a conductor of this size was incompatible with the DC-8 radome design. Mounting it on the external surface of the radome caused excessive aerodynamic drag and an installation flush with the outside skin because it would have led to major complications in the radome design.

We therefore had to find the smallest conductor that would initiate the transfer of the high-coulomb charge across the radome surface to the metal structure of the aircraft. This was a requirement that had not existed for

more on page 188

Bomarc missile, Fafnir-equipped, roars from launching pad at Cape Canaveral.

Photo: Courtesy Boeing Airplane Company

Fafnir Ball Bearings help keep Bomarc missiles "on tap"...and on target!

Used in the outboard rudder control gear box of the Boeing Bomarc, Fafnir ball bearings meet several important design requirements for Indiana Gear Works, designers of this vital missile component.

Fafnir prelubricated and shielded ball bearings and bearings with Plya-Seals, for example, provide positive, built-in protection against contaminants. These bearings remain trouble-free, require no servicing, help keep the Bomarc ready to go at moment's notice.

Uniform high quality is another must. Fafnir quality control insures bearings that consistently meet exacting tolerance and dimensional requirements, installation after installation.

Your own design problem may not involve missilery. But if it calls for ball bearings, look to Fafnir. You'll find the diversity of line and breadth of experience that assure precise answers. Write The Fafnir Bearing Company, New Britain, Connecticut.

Rudder control gear box, developed by Indiana Gear Works of Indianapolis, incorporates both Fafnir contact-type Plya-Seal ball bearing, extra-light series (left) and Fafnir double shielded type.

FAFNIR
BALL BEARINGS

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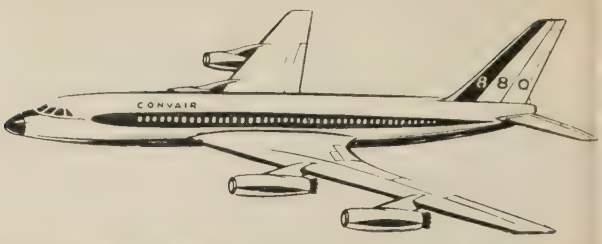
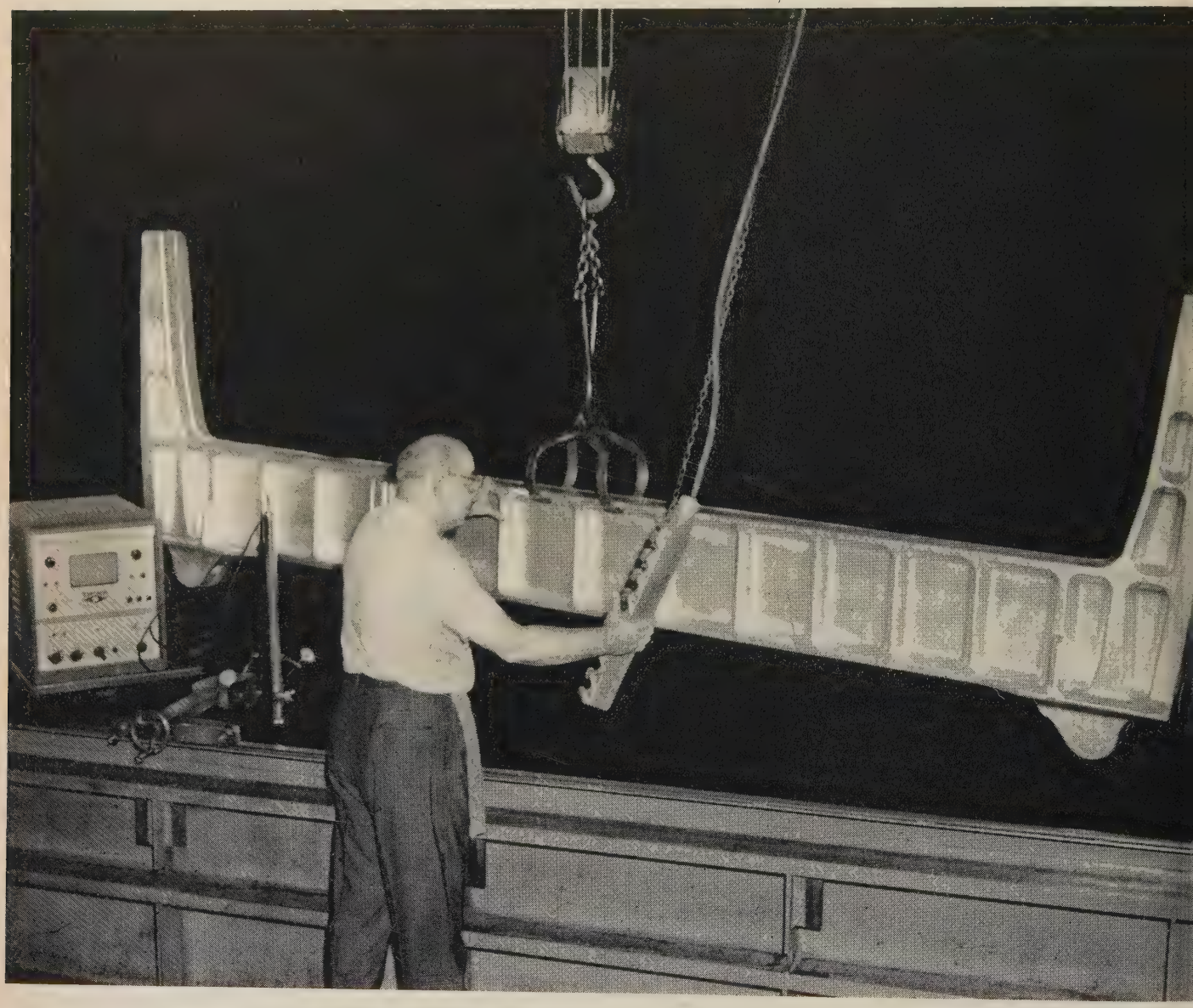
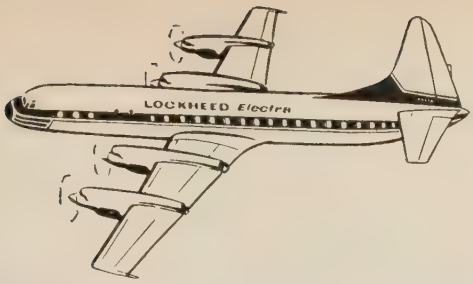


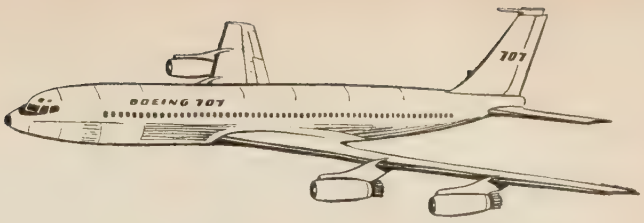


Largest closed-die forging ever made for commercial aircraft

The forging of these 657 lb. bulkheads presented unusual problems—problems of die design, of forging, and of handling. The successful solution of these problems saved a costly assembly of many smaller parts—costly both in terms of dollars and pounds.

This is a typical Wyman-Gordon accomplishment —the result of over seventy-five years of forging experience, and today supported by the greatest range of heavy forging equipment and technical know-how in the industry.

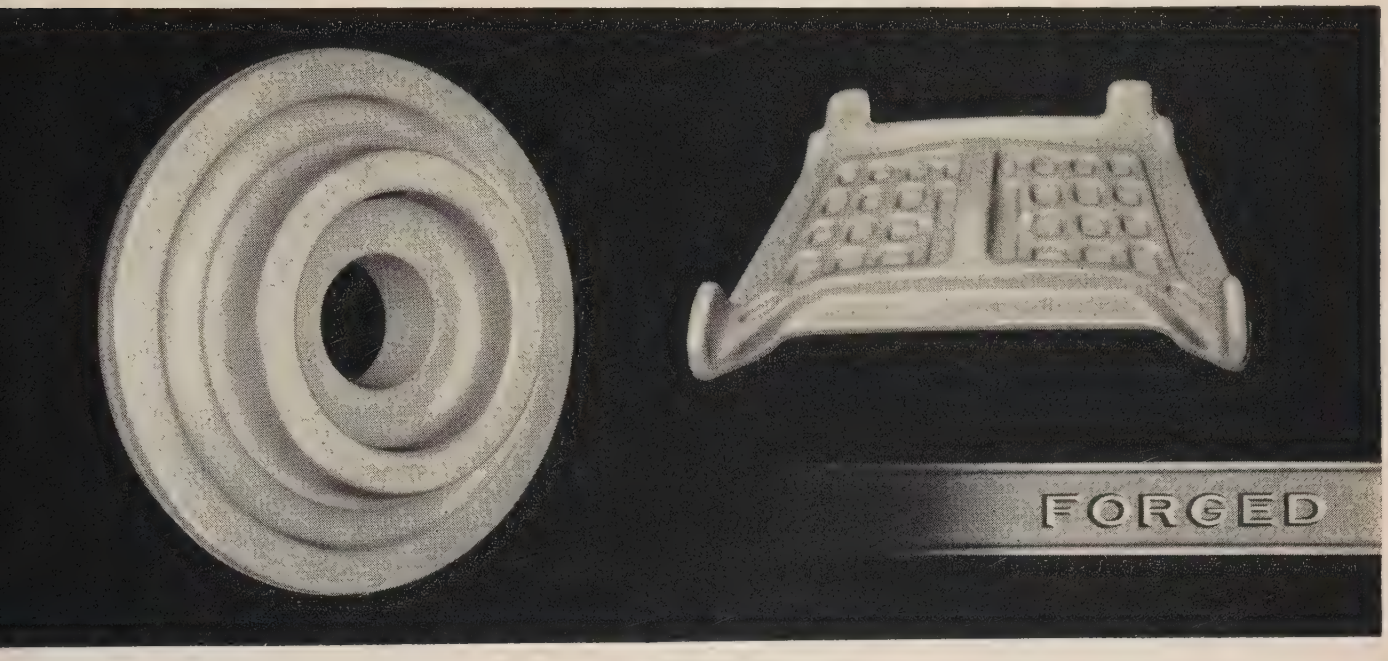




Over 1000 Wyman-Gordon forgings pace advanced jet designs

In saluting the great achievement of America's commercial jet leadership, Wyman-Gordon takes great pride in having participated so extensively in the development of the aircraft industry from its very beginning.

In World War I, the use of forgings was confined to engine parts and Wyman-Gordon made most of them. Today, from the huge main bulkhead forging at the left to the engine parts below, Wyman-Gordon forgings are in the wings, fuselage, landing gear and engines of the four newest commercial jet aircraft. These and a great variety of other vital components are forged from many types of materials: aluminum, magnesium, titanium, steel, as well as many new uncommon alloys.



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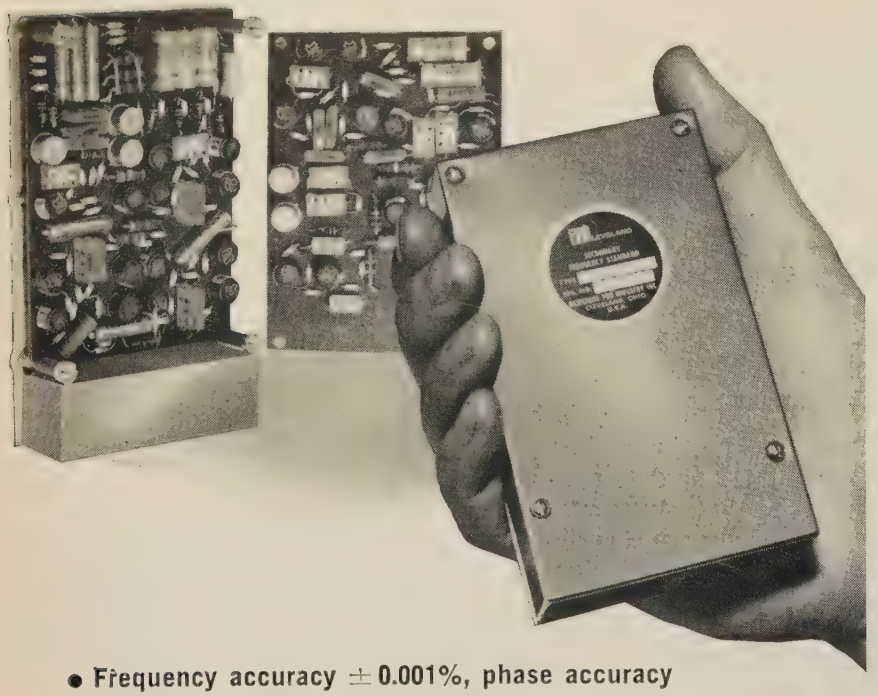
NEW FREQUENCY STANDARD USES SOLID STATE TEMPERATURE CONTROL



- Frequency accuracy ±0.001%, phase accuracy 1 degree; in missile environment
- Dip-potted 11 ounce package, 5″ x 3″ x 1″
- Five outputs, single and three-phase, accurate to ±0.001%
- Designed especially for missile use and airborne computer work

This is our most sophisticated Frequency Standard. No moving parts. Extreme accuracy under missile environment conditions. All silicon transistors. *Accurate temperature control.*

Write us for complete information or telephone collect. If you need different but equally reliable units, we are ready to help you. We suggest you check our line of Frequency Standards and Programmers in the current issue of Electronics Buyers' Guide and Space Aeronautics R & D Handbook.

OPERATING CHARACTERISTICS
Model TFS-SQ-400-28F

Output frequency	9.6 kc square wave, single phase 4.8 kc square wave, single phase 400 cps square wave, three phase
Frequency accuracy under the following conditions:	±0.001%
Temperature	25°F to 165°F
Input voltage	24 to 32 vdc
Input noise	3 v or less
Vibration	0 to 30 cps @ 0.25″ amplitude 30 to 2,000 cps; 5G, any plane
Output waveform (all)	symmetrical square wave
Input power	10 watts maximum

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previous systems—in our system, the conductor does not transfer the entire lightning strike but vaporizes to provide an ionized region for the transfer of the high-coulomb charge.

It's improbable that, on the same flight, two main lightning strokes will come from the same relative direction. In any case, lab tests show that, if a second main stroke occurs, it will probably be diverted to one of the remaining conductor strips. Also, since the conductor is smaller than the recommended size of 20,000 circular mils, it must be properly installed on the external surface and not laminated into the radome or enclose it in any restrictive medium—a strike hitting such a restricted mounting tends to destroy the surrounding region.

Tests on small samples showed that an adhesive-backed aluminum tape ⅜ in. wide and 0.003 in. thick, will protect the plastic part from damage (*Fig. 4*). The tape itself disintegrates as though it were an overloaded fuse. All installation problems with this type of conductor were easily solved, since earlier tests had shown that the pressure-sensitive adhesive on commercially available tape is adequate if the device is mounted on the outer surface of a radome. The problem of grounding the conductor strip was solved by simply inserting one end of the aluminum tape beneath the head of one of the radome's attaching flange bolts.

To find out how many conductors we should use and where we should put them, we subjected the full-scale nose mockup through another series of high voltage lightning strikes. The results showed that the conductors should be located at intervals no greater than about 18 in.

In the design of the shielding cage, two microwave test ranges were used—a radome transmission range and an antenna pattern range. The full-scale nose mock-up, including the RCA AVQ-10 weather radar antenna, was set up on the antenna pattern range (*Fig. 2*). We determined the principal plane patterns of both vertical (H-plane) and horizontal (E-plane) polarizations for various antenna orientations with respect to the nose fixture, and various lightning-strip configurations. These data were then correlated with the radar transmission loss data found for

more on page 190

New size 08 Ketay Resolver is stable over entire temperature range

This new Ketay Resolver provides stability over the entire temperature range of −55°C to +125°C. This is accomplished without the size and weight of compensating circuitry.

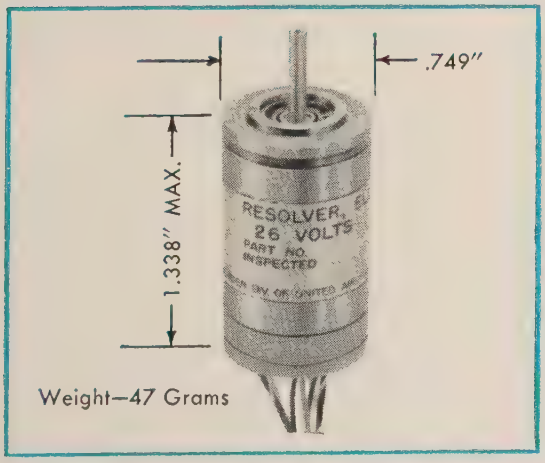
The Resolver has superior electrical characteristics.

- **High Input Impedance**—almost twice that of any existing unit.
- **Lower Phase Shift**—half that of existing units.

These features permit cascading twice as many resolvers with less degradation.

Resolver accuracy is now available in this small 08 size because of superior Ketay design. This Resolver meets or surpasses applicable military specifications for shock, vibration and humidity.

These typical specifications tell the story—



	At Room Temperature 25°C	MAXIMUM VARIATIONS Over Entire Temperature Range (Open Circuit) −55°C to +125°C
Input Impedance (ohms)	1010 ± 10% ∠79° ± 1°	± 10%
Transformation Ratio	1.059 ± 1%	± 1.0%
Phase Shift (lead)	6.0 ± 1°	± 2°
Null Voltage (total max.)	50.0 MV	± 15.0 MV
Rotor Interaxis Error (max.)	± 7′	± 2′
Stator Interaxis Error (max.)	± 7′	± 2′
Functional Accuracy (max.)	± 7′	± 3′
Frequency 400 cps		
Input Stator		
Number of Phases		
Rotor 2		
Stator 2		
Voltage Rating 26V AC		

Please write for detailed specifications and outline drawings.

NORDEN

KETAY DEPARTMENT

Norden Division of United Aircraft Corporation
Commack, Long Island, New York

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the same configurations on the radome transmission range.

We got the best results with the three lightning strips located on the top of the radome as shown in *Figure 1*. The three lower strips don't interfere with the radar installation, but they can affect the radiation patterns of the glide slope antenna mounted below the radar antenna.

With a 15-ft-diameter transmitting antenna and a 35-ft-high model support tower, we then made glide slope antenna measurements for various arrangements of the three lower lightning strips. At first, we used a 1/10-scale model of the aircraft that included the glide-slope and radar antennas as well as the radome and about 400 in. of the fuselage. It turned out that the length of the strips is critical—certain lengths reradiate, distorting the glide slope antenna pattern.

Strip length was varied in full-scale tests

When we ran the full-scale tests, we therefore varied the strip length until we were sure that it did not lie in a critical re-radiation region. The allowable variations in strip length and location fit well within the normal manufacturing and maintenance requirements. With both the upper and lower sets of strips installed, a close correlation was obtained between the 1/10-scale and the full-scale pattern measurements.

For the final high-voltage testing, (also done at LTRI), a test radome was finished to normal Douglas production standards in three steps: (1) the lightning strips were installed, (2) the outer surface of the radome was finished with Cat-a-lac paint (made by Finch Paint & Chemical, of Gardenia, Calif.) and (3) an erosion boot was applied to the nose (*Fig. 1*). The tests showed that in every case the lightning went directly to one of the protection strips rather than to any of the metal parts within this radome. Even under heavy discharges from several combined generators—with current crests of over 100,000 amp and charge transfers on the order of 100 coulombs, which completely vaporized the protective strip—the skin of the radome remained undamaged. All the maintenance that was needed consisted of taping a new strip in place.—End

DAGE *relies on new Proto-Circuits Division*

for printed wiring prototypes

Dage Television needed printed wiring prototypes—in a hurry. The project: the 1st Airborne Transistorized MIL Qualified TV System, for automatic, fully stabilized control of Photo Reconnaissance Cameras.

Dage's choice: PROTO-CIRCUITS Division of PHOTOCIRCUITS.

Only PHOTOCIRCUITS offers you such a complete, separate prototype facility. PROTO-CIRCUITS' streamlined organization—from design through tooling—cuts paperwork and overhead to the bare minimum. You get *fast service* at *low cost,* whether you're next door or across the country.

You get *better* prototypes, because PROTO-CIRCUITS uses the same highly refined production techniques utilized by PHOTOCIRCUITS.

The transition from prototype to production is a smooth one, free from awkward, costly mistakes and misunderstandings. PHOTOCIRCUITS' unique and unequalled production capacity assures a steady, on-time flow of boards, regardless of quantity.

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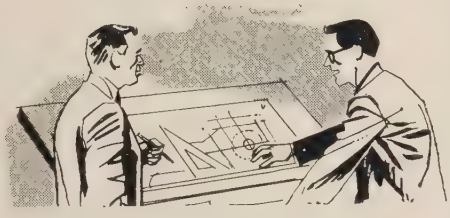
Now drill holes accurately, easily in hardest metals with Gardner-Denver K-MATIC®



IN INDUSTRY — SPEEDING THE PACE, the Gardner-Denver specialist is an integral part of the team. He works side by side with engineers and designers, helping to solve their problems, for at Gardner-Denver there's no substitute for men—our 100-year philosophy of growth.

Here's a production-line air-powered drilling unit that is only 16″ long, weighs 7½ lb.—yet develops 1000-lb. thrust for drilling in even hardest metals. It's the Gardner-Denver "K-Matic."

It brings a fine degree of hole quality to production drilling, plus production short cuts—the "K-Matic" drills holes so clean and true that reaming is often unnecessary.

The "K-Matic" is an automatic precision drilling machine—adaptable for use in stationary applications or as a portable drill. It has positive feed, rated capacity to ⅜″, and is easily mounted in any position.

For complete information, contact your Gardner-Denver representative or write for Bulletin 94-1.

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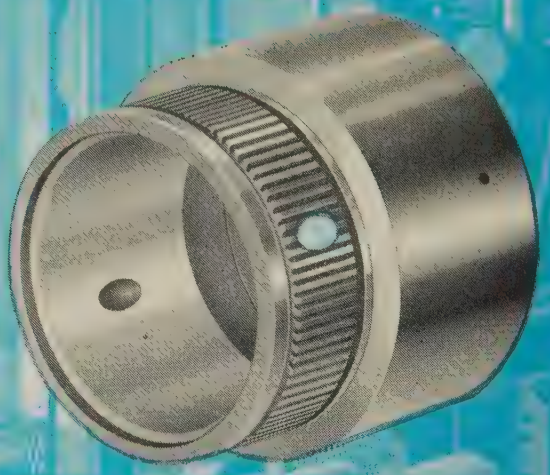
Automatic Transmission Manufacturer Specifies

OSTUCO *Seamless Tubing*



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Annealing furnace at the Shelby mill. Ostuco tubing can be bright or soft annealed, stress relieved, normalized or heat treated.

"As a leading producer of quality transmission components, we can't leave anything to chance. Our design requirements, materials specifications and manufacturing processes are under the most stringent quality control standards. And we demand as much of our vendors.

"One sure way we have found to eliminate the unpredictable is to specify Ostuco Seamless Tubing. We know from experience we can rely on the precision annealing and unvarying quality of Ostuco tubing that slashes reject rates, helps us produce parts in quantity for profit . . ."

If you want to eliminate the unpredictable in your own plant, then it's time you called your local Ohio Seamless representative. He's listed in the Yellow Pages. Or contact the plant at *Shelby, Ohio —Birthplace of the Seamless Steel Tube Industry in America.*

AA-9604

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OHIO SEAMLESS TUBE DIVISION

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IS THE PRESENT block assignment method the best way of dividing up the frequency spectrum? It may be all right for commercial services, which can be rigidly controlled—but it definitely isn't suited for military communications, which must be workable under combat conditions, answers Dr. John P. Costas, of GE's Heavy Military Electronics Dept.

Costas believes the way we now use the spectrum developed by "happenstance" and isn't based on any firm physical principles. In our drive for more and more communication channels, we've been forced to go to narrower bandwidths. To prevent chaotic interference a narrow-bandwith system needs tight operating controls. But in combat each side would control only about half of all transmitters, therefore narrow-band links would suffer outages due to their extreme sensitivity to casual interference and jamming.

WHAT WE'VE DONE with our narrow-bandwidth approach, claims Costas, is to spend a lot of money for expensive systems that, by comparison, will cost the enemy practically nothing to jam.

The military has no choice but to go to broadband systems, Costas told SPACE/AERONAUTICS. Interference is going to exist under combat conditions no matter what we do. The problem is to learn how to live with it. One solution, Costas suggests, would be to use wide chunks of the spectrum for each communications channel and separate channels by waveform coding.

By going broadband, you force the enemy to spend hundreds of dollars on jamming equipment for each dollar you spend on communications. And if he goes broadband, too, it may become pointless for him to jam you—he would be jamming his own emissions along with yours, says Costas.

EM WAVES may not all travel at the same velocity—their velocities may differ according to wavelength, speculates Meredith Beyers, research engineer for Ryan Aeronautical's Electronic Div. Writing in the company's *Ryan Reporter*, he says that, if we find that the speed of electromagnetic waves is a function of wavelength, the future of radar very likely would be changed—especially in space applications.

Edward Teller, writes Beyers, has proposed we test the accepted concept of equal-velocity EM waves by exploding an atomic bomb far out in space. The explosion would release radiations of many wavelengths that could be checked for differences in time of arrival at an earth station.

ELECTRONIC SCANNING for radar antennas is one of the high priority research programs at GE's Research Lab. A number of approaches has been tried, including ferrite phase shifters, a ferroelectric device that uses a voltage-sensitive dielectric, a gaseous-discharge phase shifter, and varactor diodes.

GE reports that it is now able to build a 360-deg ferrite phase shifter for S-band with an RF loss of about 1.5 db and a control power of less than a watt. Power is limited by heat dissipation, but GE still expects it to be in the 1-5 kw (peak) range. Responses of about 0.5 usec have been achieved with this ferrite shifter, GE told SPACE/AERONAUTICS.

In its study of varactor diodes, GE found that these produce phase shifts on the order of 100 deg per crystal at L-band, with corresponding losses of 0.5 db. Harmonic generation limits the amount of power that can be handled by the varactors.

CALL FOR PAPERS: The symposium of the IRE Professional Group on Microwave Theory & Techniques to be held May 9-11, 1960, in Coronado, Calif., is looking for papers on microwave components, systems, and physics. Send 500-word abstracts to Dr. David Medved, Convair, P.O. Box 1950, San Diego 12, Calif., before Jan. 15, 1960.

A Correction

The wrong author was given for "Electrokinetic Effects in Fluids Studied by Electronics Researchers," which appeared in the September 1959 issue (p. 161). This article should have been attributed to Thomas M. Crook, Development Chemist, Materials Engineering Dept., Aeronautical Div., Minneapolis-Honeywell Regulator Co.

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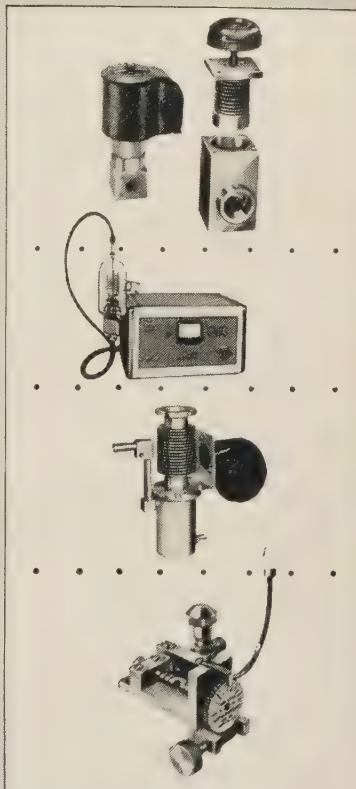
HIGH VACUUM COMPONENTS



VALVES...GAUGES...CONTROLS
PUMPS...ACCESSORIES

VALVES: Bellow sealed, brass & stainless steel • Manual • Solenoid • Pneumatic

GAUGES & CONTROLS: Non-burnout Ionization gauges, Bayard-Alpert type • Ultra-stable ionization gauge controls • Cold cathode discharge gauges and controls • Thermocouple gauges and controls

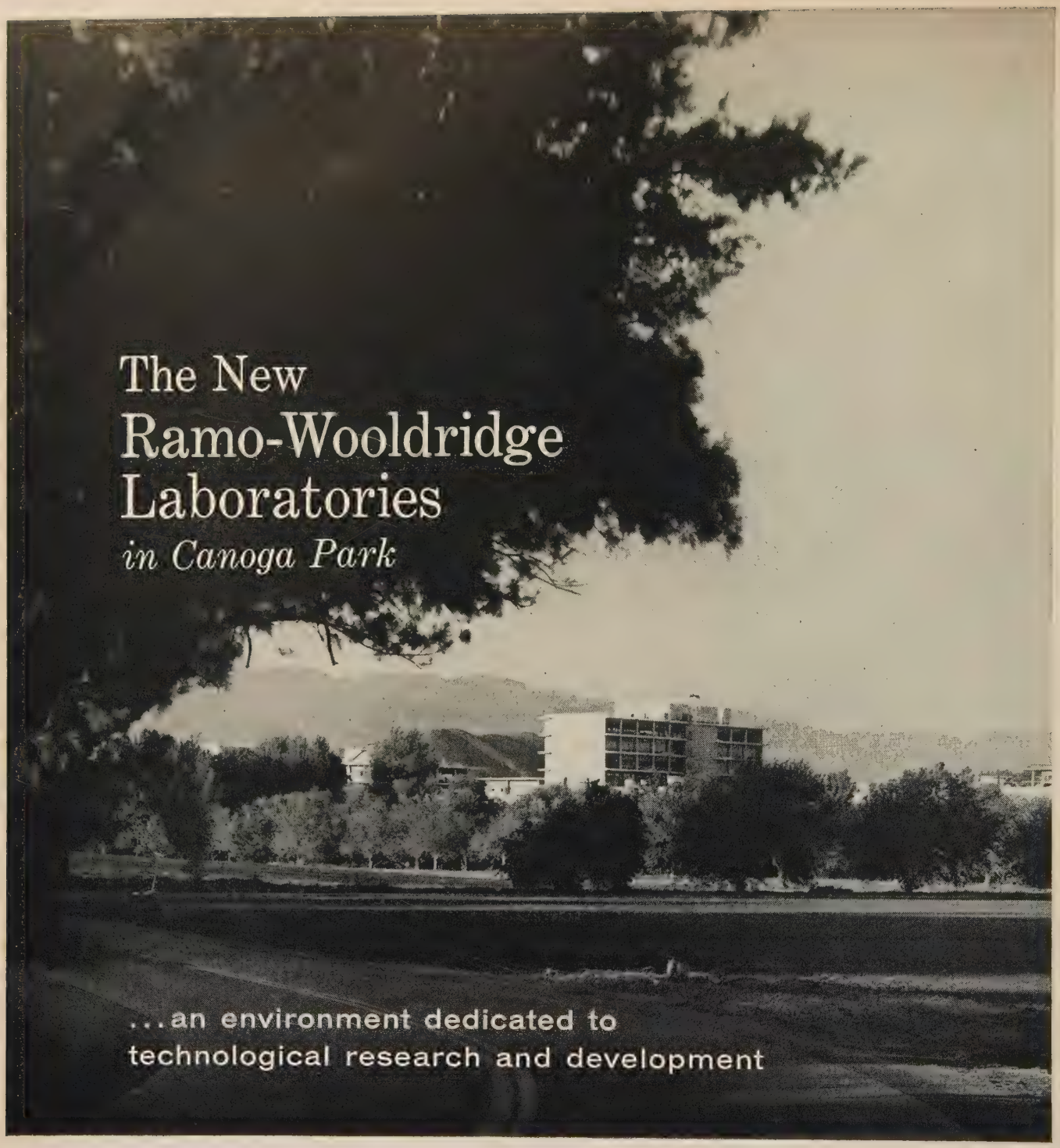
PUMPS: Diffusion pumps, air-cooled & water-cooled • Mechanical pumps, complete stock

ACCESSORIES: Standard and variable leaks • Quick couplings • Cold traps, Baffles • Electric degassing gun • "O"-ring sealed flanges • *Many others.*

FREE TECHNICAL BULLETINS or complete CATALOG. Write Department A-1437.

Veeco VEECO VACUUM CORP.
86-M Denton Avenue, New Hyde Park
Long Island, New York
HIGH VACUUM & LEAK DETECTION EQUIPMENT

Write in No. 134 on Reader Service Card



The new Ramo-Wooldridge Laboratories in Canoga Park, California, will provide an excellent environment for scientists and engineers engaged in technological research and development. Because of the high degree of scientific and engineering effort involved in Ramo-Wooldridge programs, technically trained people are assigned a more dominant role in the management of the organization than is customary.

The ninety-acre landscaped site, with modern buildings grouped around a central mall, contributes to the academic environment necessary for creative work. The new Laboratories will be the West Coast headquarters of Thompson Ramo Wooldridge Inc. as well as house the Ramo-Wooldridge division of TRW.

The Ramo-Wooldridge Laboratories are engaged in the broad fields of electronic systems technology, computers, and data processing. Outstanding opportunities exist for scientists and engineers.

For specific information on current openings write to Mr. D. L. Pyke.

THE RAMO-WOOLDRIDGE LABORATORIES

8433 FALLBROOK AVENUE, CANOGA PARK, CALIFORNIA

Check Employment Inquiry Form on Page 195

space/aeronautics

CONFIDENTIAL

December 1959
(good until 2/15/60)

Employment Inquiry Form

(NOT an application for employment)

THIS INQUIRY FORM is a service that makes it easier for the interested reader to explore employment opportunities with organizations featuring recruitments advertising **in this issue.**

To use this Form, follow these simple steps:

(1) Tear out this page.

(2) Check off the organization(s) listed below whose employment offers are of interest to you. **Use typewriter or pencil.**

(3) Turn to the back page of this Form and answer the questions on it.

(4) Mail this form (in a stamped envelope) to:

Reader-Service Dept.
SPACE/AERONAUTICS
205 East 42nd St.
New York 17, N.Y.

We will do the rest and promptly forward a copy of your Inquiry Form to each of the organizations you have checked. Depending on their specific personnel requirements, they will get in touch with you at your home.

I am interested in the employment opportunities at:

- ☐ Aeronutronic Systems, Inc.; A Subsid. of Ford Motor Co. 202
- ☐ AiResearch Mfg. Co. 262, 282
- ☐ Bell Aircraft Corp. 200, 204
- ☐ Bendix-Pacific 300
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- ☐ Boeing Wichita 202
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- ☐ Ryan Aeronautical 116
- ☐ Solar Aircraft Co. 200
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- ☐ Thiokol Chemical Corp. 110, 111
- ☐ Thompson-Ramo-Wooldridge, Inc.; Ramo Wooldridge Div. 194
- ☐ Vitro Weapons Services 198
- ☐ Westinghouse Electric Corp. 201

OTHER (Some organizations' recruitment advertising in this issue may have arrived too late for inclusion in the above list. If you are interested in the employment offers of any of these organizations, just note its name and the page number of its advertisement in this space. Please refer only to ads keyed to this form.): _____

_____

_____

NOTE: If you have an immediate interest in any special employment opportunity advertised in this issue and would like to give more details about your qualifications than can be noted on this Form, we advise you to send your resume directly to the person or department given in the advertisement. We'd appreciate it if you'd mention SPACE/AERONAUTICS in your application.

space/aeronautics

CONFIDENTIAL

December 1959
(good until 2/15/60)

Employment Inquiry Form

Please type or print (with pencil)

(NOT an application for employment)

FIELDS OF INTEREST (in order of importance, note the general fields in which you would like to work—e.g., basic research, dynamics, structures, rocket propulsion, electronic systems, pneumatics, testing, materials, production, ground support, etc.): _____

SPECIALIZED JOB EXPERIENCE (describe the specific technical areas in which you have worked —e.g., flutter, fatigue, fuel systems, circuit miniaturization, servo systems, hydraulic pumps, tool engineering, orbit mechanics, telemetry, data processing, wind tunnel testing, etc.): _____

JOBS AND EDUCATION

List your last 3 employers:

EMPLOYER	CITY & STATE	YEARS EMPLOYED	JOB TITLE OR FUNCTION

List your college and university degrees:

SCHOOL	YEARS ATTENDED	DEGREE

Special Training _____

PERSONAL DATA

AGE ..... U. S. CITIZEN ☐ YES ☐ NO If not, when do you expect to become a citizen? .....

Name: .....

Home Address: .....

Home Telephone: .....

Make sure you have checked the companies you are interested in on the other side of this Form. Then put the Form in a stamped envelope and mail it to Space/Aeronautics.

Analytical Engineers:

Want to see the whole picture?

Some engineers are content to stay in their own technological backyards. But many others prefer to work in an inter-disciplinary environment, where everything they do is concerned with the total system.

If you are interested in seeing and understanding the whole picture, rather than just a small segment of it, we think you'll be interested in System Development Corporation. Our work is concerned with the design and development of extremely large systems in which high-speed digital computers aid men in decision-making. The relative capabilities and roles of men, machines, and associated system components pose intriguing problems for creative minds.

At the present time we have key openings for engineers with proved analytical ability in the areas of communications, computers and associated equipment, simulation, information theory, weapons system analysis. Please send your inquiry to Mr. E. A. Shaw, SDC, 2424 Colorado Avenue, Santa Monica, California.

"A Mathematical Model of an Air Defense Operation and a Method of Evaluation," a paper by SDC's staff, is available upon request. Please address inquiries to Mr. E. A. Shaw at SDC.

SDC

SYSTEM DEVELOPMENT CORPORATION

Santa Monica, California • Lodi, New Jersey

11 140

Check Employment Inquiry Form on Page 195

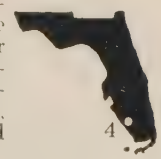
new openings in Florida with Vitro

Vitro Laboratories' Florida operation, Vitro Weapons Services, is rapidly expanding its technical staff to operate the nation's newest missile test range, the EGLIN GULF TEST RANGE.

High level supervisory and staff opportunities exist at five Florida locations: 1. Fort Walton Beach; 2. Port St. Joe; 3. Tarpon Springs; 4. Naples and 5. Key West.

ELECTRONIC ENGINEERS — with degree(s) and several years experience in Automatic Tracking Radar, Electronic Instrumentation, Phase Comparison Space Positioning Systems, Data Recording and Conversion, Telemetry or Missile Range Instrumentation.

RADAR TECHNICIANS — with training and experience in one or more of the following radar systems: MSQ-1, MSQ-1A, FPS-16, Nike, M-33, MPS-9, SCR-584, CPS-6, FPS-3 and FPS-20.



ELECTRONIC TECHNICIANS — with a solid background in electronics and several years experience in Telemetry, Data Converters, Oscillograph Recorders or Range Electronic Instrumentation.

For your opportunity to relocate in Florida with an electronics industry leader, address a confidential resume to D. D. Cox, Personnel Director, Vitro Weapons Services, 119 East Main Street, Fort Walton Beach, Florida, Dept. SA.

Vitro LABORATORIES
DIVISION OF VITRO CORPORATION OF AMERICA
Other laboratories at West Orange, N. J., and Silver Spring, Md.

Check Employment Inquiry Form on Page 195

Investigating Employment Opportunities?

Want more information about employment opportunities offered by companies advertising in this issue? Then be sure to give complete data about your job interests, experience and education when filling in the "Employment Inquiry" form.

Although not an application for employment, it provides employment managers with information to evaluate your capabilities — and in turn give your request immediate consideration.

Check the "Employment Inquiry" form for details.

Check Employment Inquiry Form on Page 195

Mr. John J
2469 Wes
Garfiel
New

RESUME FROM ROHR

TO PROFESSIONAL AND ADMINISTRATIVE PERSONNEL

Name	Rohr Aircraft Corporation
Address	Main Plant and Headquarters: Chula Vista, California (near San Diego) Manufacturing Plant: Riverside, California Assembly Plants: Auburn, Washington; Winder, Georgia
Age	Established 20 years
Health	Financial health excellent - Sales this year, $184,000,000 Backlog approaching a quarter-billion; 68% commercial
Present Position	World's largest producer of components for flight
Experience	After years of experience in the engineering and manufacture of ready-to-install power packages, Rohr today is widely diversified in many fields of structural flight components. For instance, the design and production of such major components as fuselage sections, jet pods and struts, empennage assemblies, flap tracks, missile racks, wing leading edges, etc. Perhaps even more important is Rohr's leadership in the development and manufacture of stainless steel honeycomb sandwich panels, and advanced research in the field of practical usage of exotic metals.
Reason for these openings	Rohr is selecting successful professional and administrative personnel to join its highly-regarded team.
Business References	America's major aircraft companies
Availability	We are available for interviews whenever it is mutually convenient. Please forward details of your education and experience to Mr. J. L. Hobel, Industrial Relations Manager, Rohr Aircraft Corporation, SA-5 Chula Vista, California

ROHR
AIRCRAFT CORPORATION

Openings for

DESIGN ENGINEERS

for

GAS TURBINE ENGINES

in Solar's rapidly expanding gas turbine programs in sunny San Diego

Solar has immediate openings for Preliminary Design and Product Design Engineers in its fast-moving gas turbine programs. Several new contracts have been received for industrial, non-military applications, as well as certain new military turbine development jobs. This growing diversification has created expanding challenges and opportunities. Solar is a world leader in small gas turbines, having pioneered in their design and development since 1945. The company has built and sold more than 2500 gas turbines. Join in this exciting work now for a brilliant future.

QUALIFICATIONS

B.S. in Engineering preferred, plus at least three years experience in gas turbine design. U.S. citizenship not required for some of the positions open.

SOLAR SPECIFICS

Solar is a medium-sized company (2500 people) that has been in the mechanical and aeronautical engineering fields since 1927. It is big enough to offer the most advanced personnel policies, yet small enough so you don't get lost in the crowd. Salary and performance reviewed semi-annually. Liberal relocation allowances. The special professional status of engineers is appreciated and recognized. A new 60,000 sq. ft. engineering building, necessitated by expanding research and development, will be completed soon on the edge of San Diego Bay.

SEND RESUME

Please send resume of your qualifications to Louis Klein, Dept. E-445, Solar Aircraft Company, 2200 Pacific Highway, San Diego 12, California.

SOLAR
AIRCRAFT COMPANY

LIVE BETTER, TOO! In addition to greater opportunities for personal achievement, Solar offers you the chance to live better in sunny San Diego. This famous resort area has the finest year-around climate in America. Cultural, recreational and educational facilities are excellent. You and your family will enjoy life more at Solar in San Diego.

Check Employment Inquiry Form on Page 195

INERTIAL PLATFORM ENGINEER

To be responsible for inertial navigator platform subsystems development. 2-3 years experience desired in inertial electronics and platform development.

To arrange interview call collect, Niagara Falls BUtler 5-7851, or send resume to:

SUPERVISOR ENGINEERING EMPLOYMENT

BELL AIRCRAFT CORPORATION
BUFFALO 5, NEW YORK

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IMPORTANT

In filling out Employment Inquiry Form be sure to print clearly. If you check more than one company on the form it must be photostated in order that each company receives a copy.

PROPER PROCESSING DEMANDS LEGIBILITY

You ADVANCE FASTER with ADVANCED PROJECTS and ADVANCED EDUCATION!

At the Baltimore Divisions of Westinghouse, your career can move ahead rapidly. Advanced work includes Molectronics, Advanced Weapons Systems, Electronic Counter-Measures and Reconnaissance. The Westinghouse Graduate Study Program gives you the opportunity to earn advanced degrees at The Johns Hopkins University and the University of Maryland.

Current Career Openings for Electrical Engineers, Mechanical Engineers and Physicists include:

ADVANCED ANTENNA & MICROWAVE SYSTEMS
RADAR SYSTEMS
NETWORK SYNTHESIS
DIGITAL COMPUTER DESIGN
ELECTRONIC COUNTER-MEASURES
SOLID STATE DEVICES & SYSTEMS
AUTOMATIC CHECKOUT & FAULT ISOLATION
RECONNAISSANCE & SURVEILLANCE
LIAISON ENGINEERING
ELECTRONICS INSTRUCTION
TECHNICAL WRITING
COMMUNICATIONS SYSTEMS
HUMAN ENGINEERING
ASTRONAUTICS SYSTEMS
QUALIFICATION ENGINEERING

SEND RESUME TO: Mr. A. M. Johnston, Dept. 203

Westinghouse

BALTIMORE

P. O. Box 746 3, Maryland

AIR ARM DIVISION • ELECTRONICS DIVISION • ORDNANCE DEPARTMENT

Check Employment Inquiry Form on Page 195

patterns for tomorrow

for holders of advanced degrees now exist in Boeing Wichita's tremendously expanded long-range research and development program for **PHYSICISTS** or **ELECTRICAL RESEARCH ENGINEERS** to conduct acoustics and noise control research supporting advanced designs; to analyze survival properties of advanced vehicles in present and future environments; and evaluate the potential of vehicle defense proposals... **ANTENNA DESIGN ENGINEERS** to conduct research and development leading to miniaturization of antennas by use of loading dielectrics and/or ferrites... **CONFIGURATION DESIGNERS** to create military and civilian vehicle designs based on general missions parameters... **DYNAMIC LOADS ENGINEERS** to conduct research in existing and future air/space loads... **OPERATIONS AND WEAPONS SYSTEM ANALYSTS** to estimate operational utilities of various devices under study by Advanced Design and recommended optimum design parameters, using advanced (IBM-709) computer aids. Qualified engineers should communicate their interest in any of these top positions to Employment Manager,

Mr. Melvin Vobach,
Boeing Airplane Co.,
Department N16,
Wichita 1, Kans.

BOEING WICHITA

Check Employment Inquiry Form on Page 195

RESEARCH OPPORTUNITIES
in

SPACE SCIENCES

The Space Technology Operations of Aeronutronic has immediate need for engineers and scientists who are interested in working in the stimulating and highly diversified field of space sciences. This West Coast division of Ford Motor Company has the newest facilities and most advanced equipment for carrying out highly technical work — challenging creative work that is exceptionally rewarding to qualified men.

Positions are at Aeronutronic's new $22 million Research Center, being completed at Newport Beach, Southern California. Here, overlooking famous Newport Harbor and the Pacific Ocean, relaxed California living can be enjoyed free of big-city congestion, yet most of the important cultural and educational centers are just a short drive away.

AREAS OF INTEREST

VEHICLE TECHNOLOGY
- Aerodynamic design and testing
- Rocket Nozzle and re-entry materials
- High temperature chemical kinetics
- Combustion thermodynamics
- High temperature structural plastics and ceramics
- Advanced structures

SYSTEMS DEVELOPMENT
- Aerothermodynamics
- Re-entry programs
- High temperature heat transfer
- Penetration systems
- Hyper environmental test systems

ELECTRONICS AND ASTRO SCIENCES
- Astro navigation
- Space communications and communication satellites
- Instrumentation, telemetering and data reduction
- Space environmental physics
- Advanced techniques and system studies

Qualified applicants are invited to send resumes and inquiries to Mr. G. B. Eaton, Aeronutronic, Dept. 11, Box 451, Newport Beach, California.

AERONUTRONIC
a Division of Ford Motor Company
Newport Beach
Santa Ana • Maywood, California

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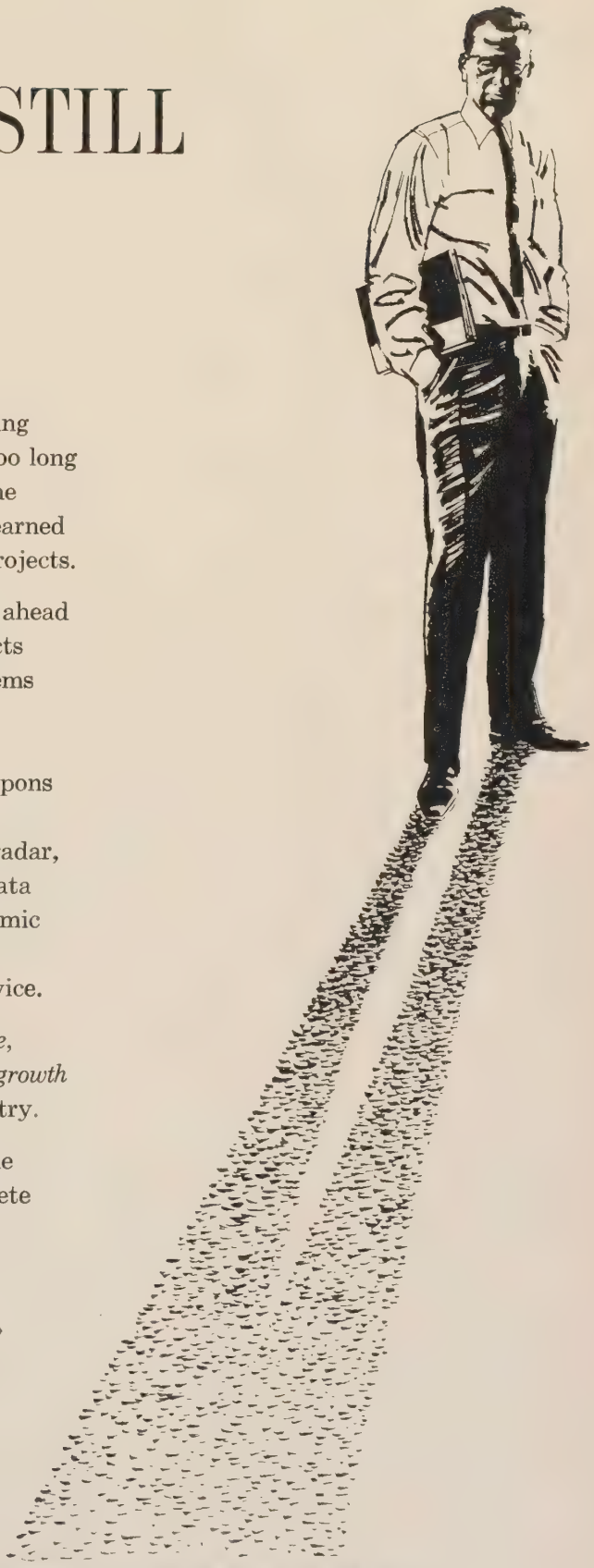
THE ENGINEER WHO STANDS STILL FALLS BEHIND



It is no secret; the economic law of diminishing returns takes effect when an engineer invests too long a period of his lifetime in repetitive work. The engineer who steps out front, is one who has learned to grasp opportunities in new fields and new projects.

Engineers at RCA Service Company can forge ahead because of its tremendous diversity in all aspects of military electronics. Responsibilities in systems engineering, field engineering, engineering publications and reliability place RCA Service Company in a key position in the growing weapons system concept. We work with advanced equipments in such fields as communications, radar, navigational aids, fire control, computer and data handling, missile guidance or tracking, and atomic energy. Our engineers are encouraged to move into new fields after a reasonable period of service.

If you are an electronics engineer *on the move*, your future is with RCA Service Company, a *growth* division of a *growth* company in a *growth* industry.

To arrange a confidential interview in our home office or in your geographic area, send a complete résumé and salary requirements to:

Mr. James Bell
Employment Manager
RCA Service Company, Dept. Y-19M
Cherry Hill,
Camden 8, New Jersey

EQUAL JOB OPPORTUNITY For All Qualified Applicants

RCA SERVICE COMPANY

A Division of Radio Corporation of America

Check Employment Inquiry Form on Page 195

ENGINEERS—SCIENTISTS

Seek and Find Daring New Goals and Rewards with General Electric's Growing

FLIGHT PROPULSION DIVISION IN CINCINNATI

Our engineers and scientists enjoy the daily challenge of new and stimulating technical problems in the largest number of advanced propulsion system projects in our history. Men with imagination and ideas are needed as Managers and Specialists in:

. . . . high Mach powerplants using hydrocarbon fuels (Jet Engine Dept.)

. . . . commercial jet powerplants (Commercial Engine Operation)

. . . . plasma and ion power sources for rockets and space vehicles; VTOL powerplants. (Flight Propulsion Laboratory Dept.)

. . . . developing production techniques for unusual materials and design configurations (Production Engine Dept.)

Advancement opportunities are multiplied—

nearly 50% of our professional people earn promotion every year. Our engineering staff has more than doubled since 1956.

● ***LOOK INTO NEW POSITIONS NOW OPEN IN OUR 4 DEPARTMENTS IN CINCINNATI FOR Graduate Engineers and Scientists experienced in:***

MECHANICAL DESIGN
- Jet, rocket powerplants
- Turbofans
- Components
- Stress, vibration
- Heat transfer
- Turbomachinery

HIGH ENERGY MATERIALS DEVELOPMENT
- Metallurgy
- Ceramics

RELIABILITY ENGINEERING
- Powerplants
- Components
- Mathematical analysis
- Accessory & Control systems

QUALITY CONTROL
INSTRUMENTATION DEVELOPMENT
WELDING ENGINEERING
THERMODYNAMICS

Send your resume to Dr. Mark Elwood, Bldg. 100, Dept. 60-ML. You will receive a prompt reply, including our 32 page illustrated brochure, "Thrust & Progress."

FLIGHT PROPULSION DIVISION
GENERAL ELECTRIC
Cincinnati 15, Ohio

Investigating Employment Opportunities?

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Check the "Employment Inquiry" form for details.

PROJECT ENGINEER — GROUND SUPPORT EQUIPMENT

To direct analysis of requirements and development of ground support equipment for inertial instrumentation and systems. Establish optimum test philosophies, direct hardware group, maintain GSE capability. Should have analytical and managerial ability and experience with inertial systems, digital circuitry and systems design.

To arrange interview call collect, Niagara Falls BUtler 5-7851, or send resume to:

SUPERVISOR ENGINEERING EMPLOYMENT

BELL AIRCRAFT CORPORATION
BUFFALO 5, NEW YORK

IMPORTANT

In filling out "Employment Inquiry Form" be sure to print clearly. When you check more than one company, the form must be photostated so that each company receives a copy.

Check Employment Inquiry Form Page 195

Check Employment Inquiry Form Page 195

product index to advertising

THIS IS A SPECIAL REFERENCE to the product information given in the advertisements in this issue. It is intended solely to help the reader make the best use of these ads. Therefore the index does not necessarily cover all the products made by each advertiser. Also, definitions and cross-listings are not intended to exhaustively describe each product but merely to make sure that each product can be found with reasonable ease by the reader looking for it.

Similar indexes to services and employment opportunities featured in ads follow this index.

Advertisements for which complete proofs were not available to the Editorial Department by the closing date are not necessarily covered by these indexes. (Proofs can be forwarded internally by the Production Department only for advertisements meeting the closing dates.)

For more detailed information on any product or service advertised in this issue or featured in its Product and Data Reviews, use the handy Reader Service Card.

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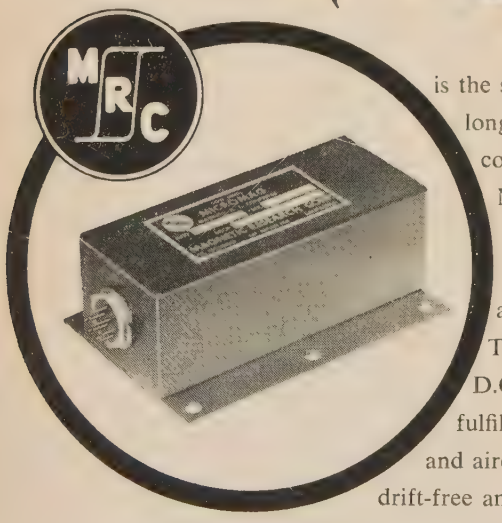
Number One of a simple series on symbology...

The Sign of the Kame

In the Japanese Shinto religion the sign of Kame (the Tortoise)



is the symbol of longevity. On the contemporary scene, the letters M.R.C. also mean longevity... longevity guaranteed by creative design and precision manufacturing. The all-new, wide band D.C. Amplifier fulfills a critical need of missile and aircraft design engineers for a stable, drift-free and multipurpose amplifier with a wide range of response. The M.R.C. D.C. Amplifier utilizes static, magnetic modulation instead of the usual electro-mechanical chopper. This results in an inherently rugged design.

SPECIFICATIONS

Input (nominal)	0 to 5 millivolts D.C.
Output	0 to 5 V D.C.
Excitation	28 V D.C. (unregulated)
Linearity	±1%
Total Gain	0-1000
Pass Band	flat beyond 100 cps
Gain Stability & Zero Drift	better than 1%

For additional information on M.R.C.'s complete line of magnetic and transistor amplifiers, write for Data File MA-1000.

MAGNETIC RESEARCH CORPORATION

Pacing the Industry in Astro-Magnetics

3160 WEST EL SEGUNDO BOULEVARD, HAWTHORNE, CALIFORNIA

Write in No. 135 on Reader Service Card at start of Product Preview Section

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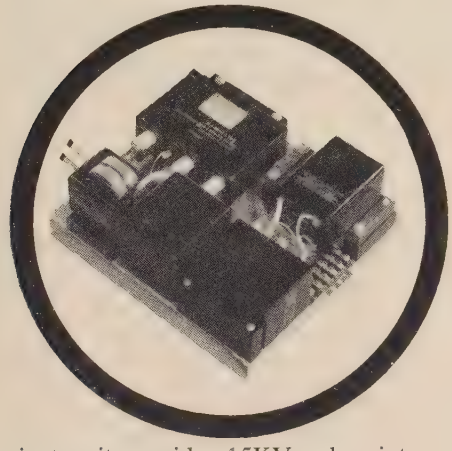
Speaking of longevity...

M.R.C. offers a new series of Solid State Pulse Modulators for timing circuits, search radar, airborne radar and missile guidance.

One outstanding member of this group is the Model MP505 Airborne Pulse Modulator. This unit is used as a pulse modulator for high power missile beacons. Using only 250 watts of power, this effi-



cient unit provides 15KV pulses into a MA206 magnetron load. The pulse width is .25 microseconds at a repetition rate of 2000 pps.

The MP505 is hermetically sealed and weighs less than 7.5 lbs. Solid state-magnetic pulse generator systems are available in ranges from .1 to 10 megawatts, with repetition rates as high as 10,000 pps.

For complete information on the entire pulser series, write for Data File MP1100.

MAGNETIC RESEARCH CORP.
Pacing the Industry in Astro-Magnetics
3160 WEST EL SEGUNDO BOULEVARD
HAWTHORNE, CALIFORNIA

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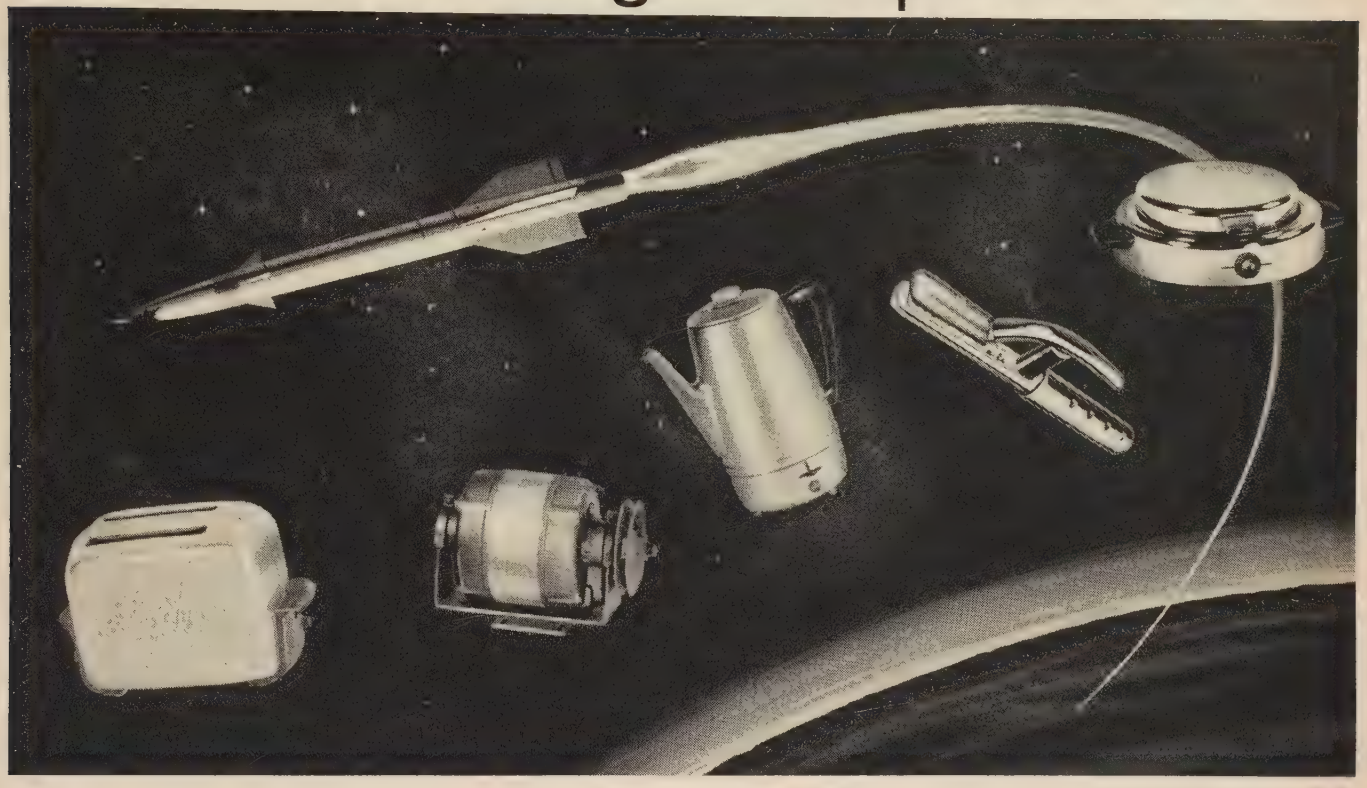
How plastic laminates behave at high temperatures



"How high is up?" to quote an old riddle, just about describes the high temperature possibilities of plastic laminates.

To a missile expert a high temperature might be in excess of 5000°F or of 20,000°F. To many of us high could mean 180°C, or over 250°C.

The key to the situation is Temperature Endurance. Where high temperature resistance is required, as in missile applications, the useful life of the part may be a matter of seconds. Under these conditions recent experiments show that reinforced organic plastics can compete with refractory metals and ceramics. And there are indications that the "old reliable" phenolic resin laminates might outshine the newer resins in this respect.

All of this is exciting yet the larger need is for plastic laminates which will endure moderately elevated temperatures for a long time. The A.I.E.E. defines Class H and Class C materials as those which "by experience or accepted tests" can be shown to be capable of operation at temperatures of 180°C or 220°C respectively.

Tests of 7 standard grades of plastic laminates were made by members of the Laminated Products Section of N.E.M.A. (Table 1).

Obviously, Grades XX and LE are not 180°C material. Grade XXXP has excellent electrical properties after exposure. Grades G-5 and G-7 have excellent mechanical properties and good electrical properties.

Similar tests were made on 4 standard grades at 250°C with these results:

Table 1
Properties at 180°C after 1000 hours exposure to 180°C

Grade	Flexural Strength	Dielectric Strength	
		Perpendicular	Parallel
	psi	V.P.M.	V.P.M.
XX	5600	*	170
XXXP	4100	530	250
LE	400	*	*
AA	5400	55	76
G-5	17500	112	143
G-7	18700	290	200
G-10	5200	160	178

*Specimens blistered

Table 2
Properties at 250°C after 1000 hours exposure to 250°C

Grade	Flexural Strength	Dielectric Strength	
		Perpendicular	Parallel
	psi	V.P.M.	V.P.M.
AA	800	50	54
G-5	1900	108	77
G-7	11800	211	250
G-10	not tested	112	100

These same materials often are satisfactory at temperatures in excess of 5000°F for a number of seconds required in these types of applications.

Just as the tests hold great promise for the future of laminated plastics in the very high temperature field, so do the tests in the moderately elevated temperature applications demonstrate the remarkable endurance of plastic laminates.

Consider Other Properties

The thermal resistance and thermal endurance of laminates such as Synthane must be viewed in relation to other properties. Commercial applications include toasters, ironers, space heaters, water heaters, welding equipment, motors, generators, circuit breakers, electric furnaces and ovens, jet engines. These applications may require also resistance to moisture, chemicals, wear, ageing; ease of fabrication, mechanical strength, light weight. Since the life of a laminate in a heat environment may be affected by conditions not present during actual tests, special test procedures may have to be established. Synthane Corporation will be very happy to help you find a laminate suitable for your temperature-life problem. Write Synthane Corporation, 55 River Road, Oaks, Pa.

SYNTHANE

CORPORATION, OAKS, PENNA.

Laminated Plastics for Industry

Sheets, Rods, Tubes, Fabricated Parts
Molded-laminated, Molded-macerated

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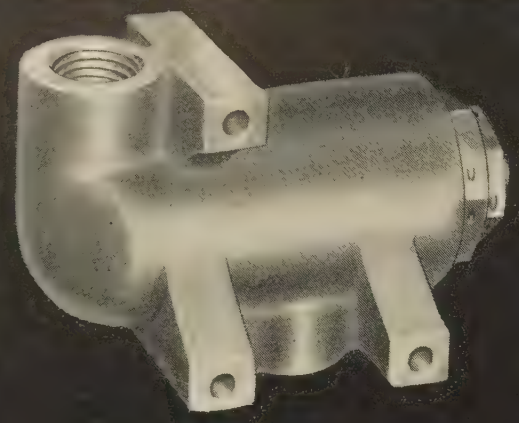
NEW Fluid Regulators Product



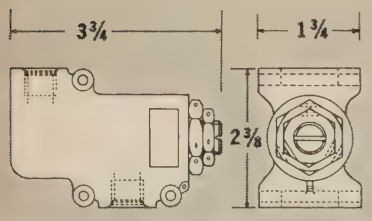
High Pressure RELIEF VALVE

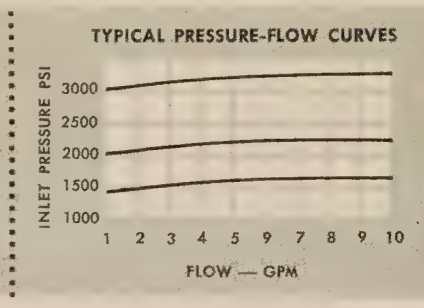
No Chatter . . . Only 11 ozs.

- **Good Repeatability**
- **Accurate Pressure Control**
- **Extremely Stable**
- **No Hysteresis**

This precision valve is just one of the many pressure and flow control valves and devices Fluid Regulators Corporation has designed and produced to meet customer's exacting weight, size and performance specifications. It features low pressure rise and modular (cartridge) construction for easy maintenance.

For good, fast, practical solutions to your hydraulic pressure and flow control problems write us today.





SPECIFICATIONS

- Performance: exceeds MIL-V-5523B
- Outline And Mounting: meet AN 6279-6
- Mounts: on either side
- Operating Pressure (adjustable): 100 to 4,000 psi in three ranges
- Temperature Ranges: —65° to +275° F.
- Weight: 11 oz.
- Ports: AND 10050-6
- Materials: Aluminum And Stainless Steel
- Part No.: 7485

Write for detailed literature

Designers and manufacturers of hydraulic and fuel valves for aircraft missiles, rockets, ground handling and support equipment.

Fluid Regulators CORPORATION

313 Gillette Street • Painesville, Ohio • ELmwood 2-3319

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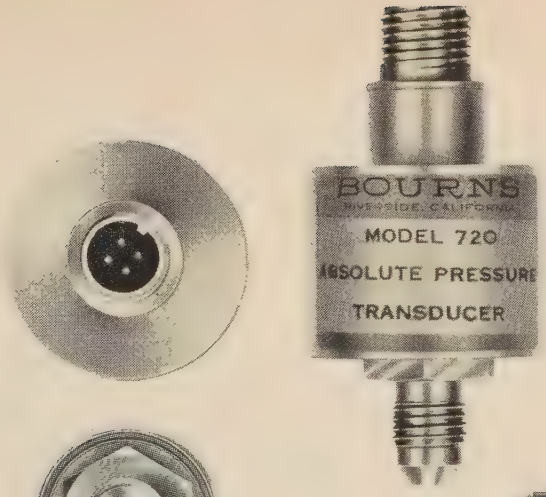

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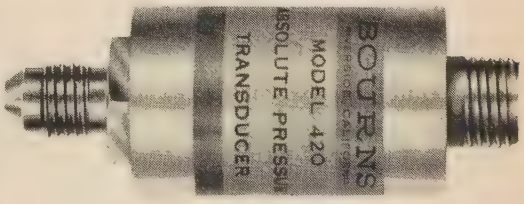


Bourns Pressure Transducers

SUBMINIATURE SIZE

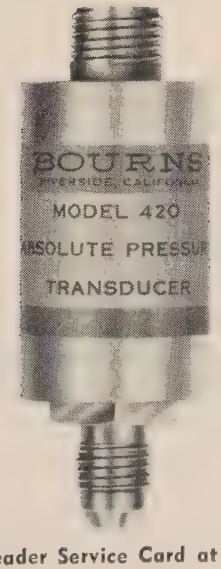
HIGH RELIABILITY

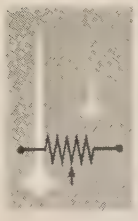
These rugged miniaturized instruments weigh less than 4 ounces. Nevertheless, each unit is built to the same uncompromising standards that have won a place in every major missile program for Bourns instruments. At ±35G vibration, these compact instruments deliver a high level, low error, noise-free signal. Available in absolute or gage pressure versions, over a wide pressure range, the 420 and 720 lines will meet your most exacting performance and reliability requirements. These units, with a wide selection of mountings, pressure fittings and electrical connections, illustrate Bourns' ability to translate the most stringent requirements into high-performance transducers you can depend upon. They prove the statement—*in pressure transducers . . . it's Bourns for leadership.*

Specifications

	Model 420	Model 720
Pressure ranges	0-15 to 0-350 psi	0-350 to 0-3500 psi
Operating temperature	—65 to +165°F	—65 to +165°F
Static error band	1.0 to 1.3%	1.0 to 1.3%
Dimensions	1.0" x 1.6"	1.31" x 1.25"
Weight	4 ounces	4 ounces

Write for complete technical data





BOURNS

Bourns, Inc., Instrument Division
6135 Magnolia Ave., Riverside, Calif.
Field Engineering Offices:
Huntington Station, L.I. and Dallas, Texas
Pioneers in potentiometer transducers for position, pressure and acceleration. Exclusive manufacturers of Trimpot®, Trimit®, E-Z-Trimit®.

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NEW HIGH IN TENSION BOLT PERFORMANCE!

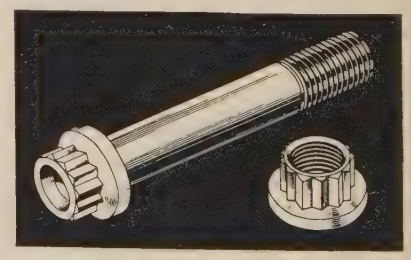
260,000 psi—with over twice the fatigue life of an MS20004

SPS laboratories for advanced fastener research are one of the few facilities in the world capable of developing and adequately testing a bolt such as the EWB 26. Each shipment of these new high performance fasteners is accompanied by laboratory certification.

Introduction of the EWB 26—a 12-point external wrenching bolt with a tensile strength range of 260,000 to 290,000 psi—marks a major breakthrough in the search for fasteners with increasingly higher strength-to-weight ratios. Pound for pound, this is the world's strongest bolt, not only in tensile values but also in shear and fatigue.

A tangible result of SPS's intensive research program, the EWB 26 offers significant advantages in airframe, missile and spacecraft applications. For example, you can use an EWB 26 in place of a conventional bolt two to three sizes as large—and proportionately heavier. Or, conversely, you can achieve desired holding power with fewer bolts, thus reducing total fastener weight. Again, in a fix, you can substitute EWB 26 bolts size for size in existing designs, with a substantial increase in strength and reliability.

The EWB 26 is one of a series of new SPS super fasteners designed to meet performance demands of our accelerated technology. And in anticipation of tomorrow's requirements, SPS laboratories are already testing even more remarkable products—fasteners of truly incredible strength.



Performance characteristics of SPS EWB 26 ultra-high-strength tension bolt at temperatures up to 550°F:

Tensile strength	260,000 psi
Shear strength	156,000 psi
Yield strength	215,000 psi
Fatigue strength (at 65,000 cycles)	135,000 psi

EWB 26 bolts—and companion FN 26 locknuts—are available from stock in standard sizes #10-32 through ⅞-14. Bolts are cadmium plated by vacuum deposition. For complete technical data, request new Bulletin 2527.

AIRCRAFT/MISSILE Division

JENKINTOWN 54, PENNA.

SPS WESTERN, SANTA ANA, CALIF.

sps

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equipment briefs

DESK-SIZE DIGITAL COMPUTER

A SMALL, powerful stored-program computer that uses solid-state components and advanced computing circuits has been announced by International Business Machine Corp., Data Processing Div., 112 E Post Rd., White Plains, N.Y. The 1620 data processing system consists of a central processor and a paper-tape reader and punch. The central processor includes the operator's control console, a modified, built-in electric typewriter, the magnetic core storage, and arithmetic and logic units.

The magnetic core storage has a capacity of 20,000 alphanumerical digits, each of which is individually addressable and can be made available immediately for processing. All data entering the computer are placed in the core storage as decimal units.

Because it uses a variable field length, only useful data are stored in the 1620's memory. The results are greater capacity and faster access and processing speeds, says IBM.

Addition, subtraction, and multiplication are done automatically by a table-look-up method. Division is performed by an available subroutine.

The paper-tape punch and reader and the electric typewriter are the input-output devices. The tape reader can read an eight-channel paper tape at a rate of 150 characters per second.

Processed data are fed from the core storage to the tape and typewriter units. The tape punch records data on eight-channel paper tape at 15 characters per second. The typewriter prints automatically at 10 characters per second.

For programing, a two-address instruction format is used. IBM's two advanced programing systems Fortran (*for*mula *trans*lation) and the symbolic programing system—can be used with the 1620. In addition, a comprehensive library of mathematical and statistical subroutines is available from IBM for use with the 1620.

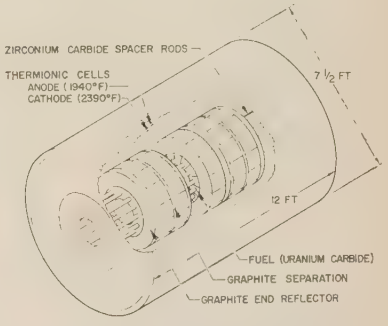
No air-conditioning equipment is needed for 1620, so installation and operating costs are unusually low. The system will sell for $74,500 and rent for $1,600 per month. Write in No. 74 on Reader Service Card for more information.

TESTING BRAZED HONEYCOMB

IT MAY soon be possible to locate and permanently record at production speeds unbonded areas in brazed honeycomb sandwich. A new "Thermographic" method that can be adapted to both flat and curved shapes is under final evaluation at the Magnaflux Corp., 7300 W. Lawrence Ave., Chicago 31, Ill.

This detection technique produces an exact pattern of every good bond point between core material and skin. It also shows up over-heavy braze. A dark brown pattern is produced that remains fixed on the skin until removed by a solvent.

Patterns can be photographed for record purposes or left on indefinitely for examination. The Thermographic installations as presently conceived will include full automatic controls, a conveyor spray system, and control heat applications. Write in No. 54 on Reader Service Card for more information.



NUCLEAR REACTOR FOR ION PROPULSION

LOCKHEED Aircraft's Missiles & Space Division, Sunnyvale, Calif., has proposed a nuclear reactor for the direct conversion of atomic power into electric energy. Enough power is generated to keep an ion-propelled spacecraft going for one year.

Heat from the reactor "boils" electrons off the cathode, which is at 2390 deg F. These fugitive electronics "condense" on the cooler anode, which is at 1940 deg F, and produce an electric current. The process is duplicated in each of the small thermionic cells arranged around the outer cylinder. The total yield of the 200 cells comes to 1000 kw.

He has brainstorms ...to order

He's one of a group of AMF scien tists who develop solutions to th utterly original problems of moder defense and human penetration o space. He doesn't build *better* mouse traps. His business is completel new kinds of traps for mice tha have never been caught.

Examples: A method of recoverin potable water from human wast fluid, the major source of water in sealed space vehicle... Methods o analyzing the effects of a nuclea blast on the earth's crust, how i changes the character of soil an rock, how its shock is propagated what sort of building structure wi withstand it... Platforms on whic will be mounted primary standard calibration instruments for missil guidance systems. These platform must be so vibration-free that natu ral earth movements must be com pensated for. Platform vibration are limited to millionths of an inc ...A method of predicting tempera tures in missile nose cones upo re-entry.

Single Command Concept

These samples of creative ingenu ity reflect the resourcefulness AM brings to any assignment.

AMF people are organized in *single operational unit* offering wide range of engineering and pro duction capabilities. Its purpose: t accept assignments at any stag from concept through developmen production, and service training. and to complete them faster...in

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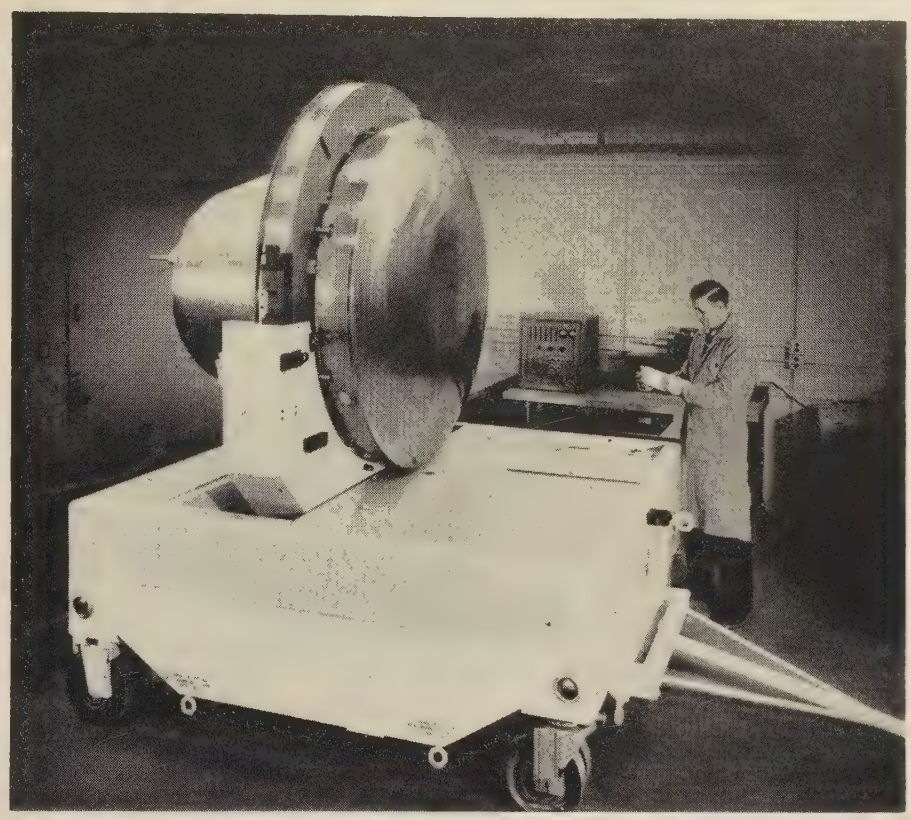
Write in No. 141 on Reader Service Ca

space/aeronautics **product of the month**



WEIGHT AND CG LOCATER
for missile nose cones

Feature Product Award

DECEMBER 1959

The Dynametrics Corp., Burlington, Mass., has developed a weight and CG locater which is precision-built for accurate field evaluation of ICBM components. It makes it possible to determine re-entry attitudes with high accuracy by providing a convenient readout weight and CG along the roll, pitch and yaw axes. It can resolve 0.001 in. from maximum weight down to as little as 45 lb and has an overall accuracy of 0.01 in. over its specified operating range of 1800 to 4500 lb. Longitudinal and radial moments are automatically displayed in large numerals that can be read from a distance of 15 ft.

The locater can handle a complete re-entry vehicle without damaging its critical surface. A special ring is provided for mounting the nose cone. The whole unit can be assembled by two men in the field in less than 30 minutes.

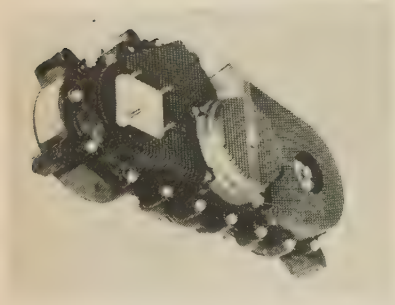
Write in No. 142 on Reader Service Card at start of Product Preview Section

This award is made in recognition of outstanding service performed through the development and manufacture of a product contributing to the advancement of the aerospace industry.

Randolph Hawthorne
Editor

product preview

GEAR BOX
has two speeds



This two-speed, automatic shifting gear box is designed to overcome specific problems encountered with the use of 400-cycle constant speed drives, used on the Northrop T-38 supersonic jet trainer. It is a twin-engined jet, with one gear box drive per engine supplying separate and independent electrical systems, according to **Waste King Corp., Dept. S/A, 4600 Pacific Blvd., Los Angeles, Calif.**

Each of the two gear boxes drives a 400-cycle 8KVA alternater and hydraulic pump supplying one-half the electrical power and one-half the hydraulic power for the aircraft.

Write in No. 460 on Reader Service Card

STATIC INVERTER
has unique design

A lightweight static inverter that has no moving parts and incorporates silicon semi-conductor and magnetic components capable of operating at a 250-deg F temperature is reported to be unique among dc to ac conversion units. The inverter, which features both efficiency and reliability, is designed for use in missiles, manned aircraft, auxiliary power systems, ground support power supplies, and electric power conversion units, says **Pesco Products Div., Borg-Warner Corp., Dept. S/A, 3310 Vanowen St., Burbank, Calif.**

The device includes a control oscillator, logic system, power section, and voltage regulator, all modular units, and functions by means of the programed control of six switching elements. The logic system directs oscillator-generated clock pulses to provide proper sequential control of the switching elements, resulting in a three-phase output. Operating characteristics include: output ranges to three kva and load unbalance of 100 per cent; frequency stability of 0.5 to .002 per cent; output voltage regulation of ±3 per cent; overload to 300 per cent, and a harmonic content of under five per cent.

Write in No. 461 on Reader Service Card

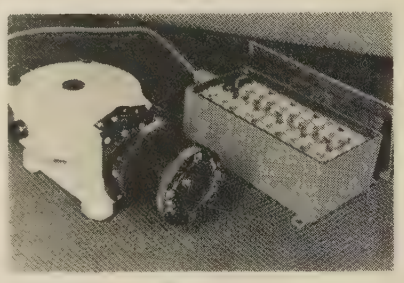
BRACKETS
are fracture-proof

Hypersil core extruded aircraft aluminum transformer brackets are fracture-proof and shock and vibration resistant, says **Olympic Products Co., Inc., Dept. S/A, Alpha, N.J.** They are designed to fit all recommended hypersil core transformers.

Hole sizes range from .157 to .213, with or without pem nuts.

Write in No. 462 on Reader Service Card

WIDE-ANGLE LENS
withstands 50 Gs



This motion picture wide-angle lens, with a GSAP mount designed to withstand accelerations as high as 50 G's, is for missile scoring systems and is suited for installation in restricted quarters inside missiles or aircraft, says **Traid Corp., Dept. S/A, 17136 Ventura Blvd., Encina, Calif.** Designated 725, the 16mm lens has a speed of 5/1.5 and 110 deg field of view.

It forms a round image of .297 in diameter in the film frame and has a focal length of 0.1655 in, or 4.038 mm.

Write in No. 463 on Reader Service Card

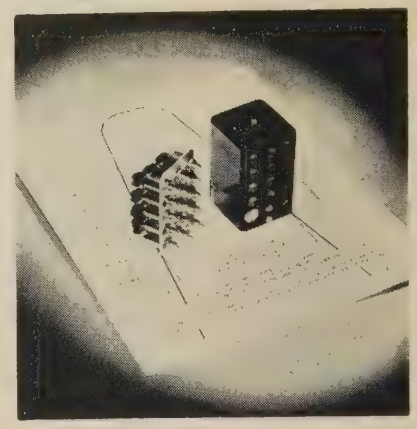
MAGNETIC CLUTCH
boosts torque-size ratio

An increase of up to 400 per cent in output torque over clutches of comparable size is offered by the Type C-18 magnetic clutch, according to **Guidance Controls Corp., Dept. S/A, 110 Duffy Ave., Hicksville, N.Y.** Output torque for friction face models is 80 oz-in (minimum) at 24 to 28 V dc, and breakaway torque is .15 oz-in energized and .05 oz-in de-energized.

General specifications for the clutch, which has a 13.5-oz maximum weight, includes zero backlash and zero to .0003-in end play maximum. Engagement time is four msec at the maximum recommended speed of 5000 rpm, and power consumption is 3.5 W. A standard servo mount is included, and input and output shafts are concentric with the servo mounting pilot within .0015 TIR.

Write in No. 464 on Reader Service Card

IF FILTER
weighs less than 12 oz.



This miniature IF filter has a center frequency of 460 Kc and has a high selectivity of 6 db down at 440 kc and 480 kc and 90 db down at 415 kc and 505 kc. The insertion loss is about 14 db at an impedance of 17,500 ohms and 43 db at 75 ohms, says **Hermetic Seal Transformer Co., Dept. S/A, 555 N. 5th St., Garland, Texas.**

One hundred to 6 db bandwidth ratios of less than 2 are obtained, depending on shape and impedance mismatch of from about 5 to 25 per cent of center frequency. At 500 kc center frequency, there is less than 1 db per section insertion loss.

Write in No. 465 on Reader Service Card

POTENTIOMETER
is gravity-sensing unit

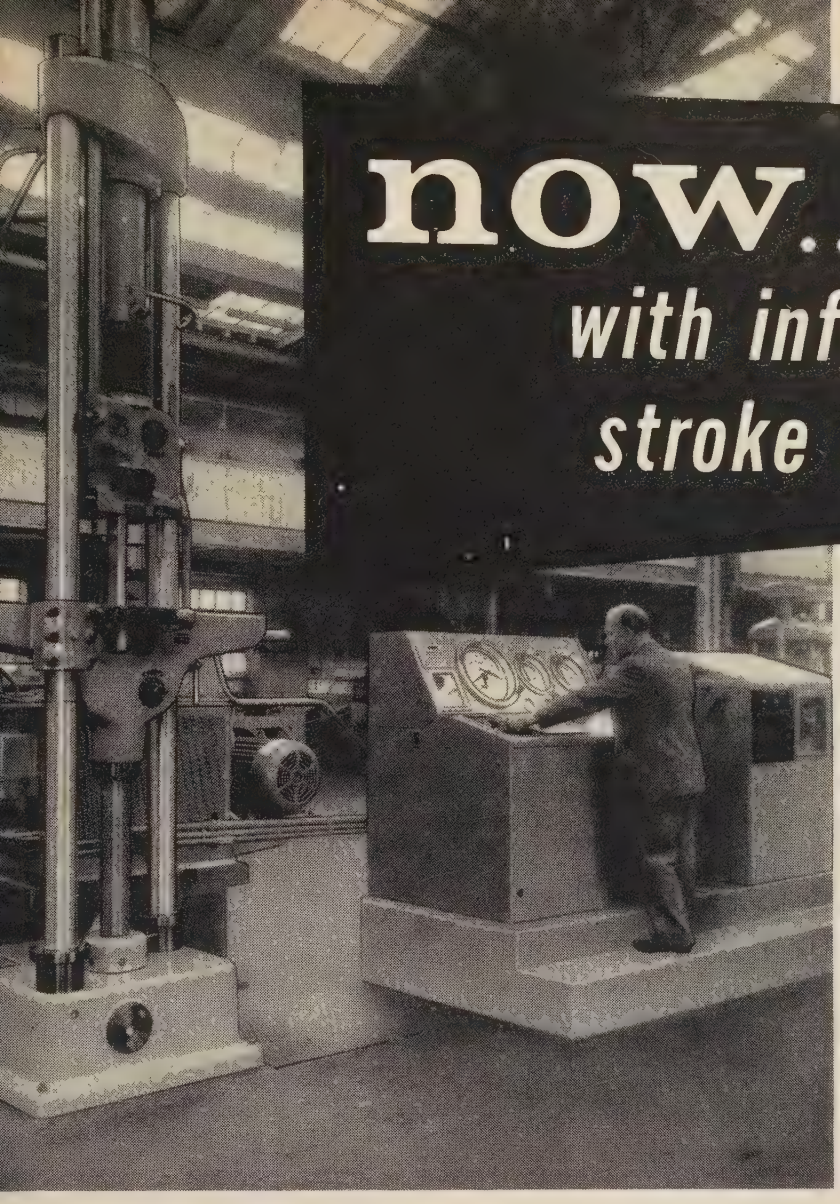
The EP 1012, a gravity-sensing electrolytic potentiometer designed to operate on the movement of an air bubble in a curved glass tube has been introduced by **Hamlin, Inc., Dept. S/A, 1316 Sherman Ave., Evanston, Ill.** The device is recommended for use in gyroscope-correcting mechanisms and remote tilt measuring devices.

Three electrodes, sealed in a tube partially filled with an electrolytic solution, are arranged to show equal resistance from the two operational electrodes to the common electrode when the unit is in a horizontal position. Tilting moves the air bubble and resistance increases on one electrode, decreases on the other. Used as one-half of a bridge circuit in a 1000-ohm bridge, with 12 V applied, the EP 1012 provides zero output at the horizontal position. A ¼-deg tilt results in an output of four V and a ½-deg tilt, eight V. The unit reaches saturation at about ¾-deg tilt.

Write in No. 466 on Reader Service Card

more on page 218

Write in No. 143 on Reader Service Card



now...fatigue testing with infinitely variable stroke and frequency

LOSENHAUSEN HYDRAULIC FATIGUE TESTING MACHINE WITH PROGRAMMER.

NEWLY AVAILABLE from Riehle, this Losenhausen hydraulic fatigue testing machine permits complete load and cycle flexibility. Consisting of a console, pulsator and loading unit cylinder, the Losenhausen machine generates strokes up to 10″ at low frequencies and modest strokes can be accommodated at frequencies approaching 1000 cpm.

The console measures and indicates the load developed on each cycle, as either fluctuating in tension or compression or as alternating between maximum compression and tension.

A programmer that automatically controls frequency, load and stroke can also be supplied. Another valuable Losenhausen advantage, this precise method of setting up tests save time and eliminates step-by-step errors.

FOR ENTIRE ASSEMBLIES

Simply through the use of general purpose testing cylinders, the Losenhausen machine can fatigue test full-scale assemblies and large components. These cylinders apply individual loads at various points.

Standard machines have dynamic capacities ranging from 12,000 to 200,000 pounds. Machines of higher capacity are special. General purpose testing cylinders are available in dynamic capacities from 2,000 to 100,000 pounds.

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He is looking at the conquest of space

The man above is studying the vibration reaction of a Union 6 PDT miniature relay, at the reliability laboratory of Convair-Astronautics, San Diego, Calif.

Result: These Union Switch & Signal relays were chosen by Convair for the guidance of their Atlas missile, launched into orbit December 18, 1958.

Extreme reliability was needed in the Atlas guidance system, to insure precise control of flight. And the Union relay subjected to thorough testing, answered that need.

Part of the 6 PDT relay reliability can be laid to its small size and its clean, simple, rotary design which gives it fewer inherent problems than other relays. In tests at Union Switch & Signal, it has proved its ability to give outstanding performance in critical dry-circuit control applications—was absolutely solid to 2,000 C.P.S. at 15 G!

The relay used in the Atlas is just one of a complete line of *dependable* relays designed by Union Switch & Signal. Write today for complete technical details.

See us at Eastern Joint Computer Conf. Dec. 1, 2, 3, 1959, Statler Hilton Hotel, Boston, Mass. Booths #1 and #2.

"Pioneers in Push-Button Science"

UNION SWITCH & SIGNAL
DIVISION OF WESTINGHOUSE AIR BRAKE COMPANY
PITTSBURGH 18, PENNSYLVANIA

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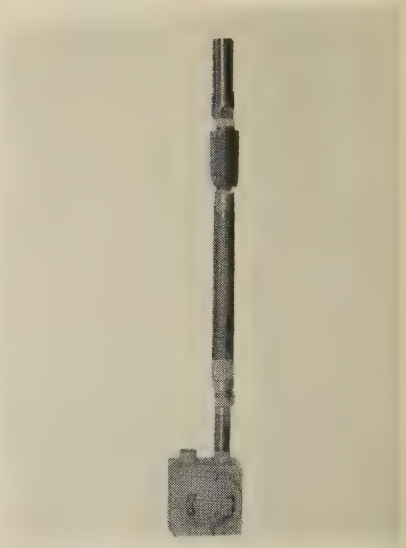
SENSOR for cryogenics



A sensing unit originally developed for missile applications and now in use on propellant loading systems will detect cryogenic liquids or fuels in a transfer line or vessel to very low levels, says **Missile Equipment Div., Minneapolis-Honeywell Regulator Co., Dept. S/A, Pottstown, Pa.** Levels of liquid gases and fuels can be detected to 1/16 in. or less, and the probe will withstand a pressure of 250 psi at −297 deg F, and a liquid velocity of 18 ft/sec.

The three-part control unit contains a detector probe, amplifier, and connecting coaxial cable. Liquid changes the probe's capacitance as it fills the space between the stainless steel concentric cylinders making up the probe. The change is transmitted to the transistorized amplifier, where it is converted to energize a dpdt relay. Both coaxial cable and amplifier feature explosion-proofing.

Write in No. 467 on Reader Service Card

GAIN CHANGER has compact design

The seven components of this gain changer have been housed in a package only six in. long and 1.375 in. in diameter. The Type 9805-12, which operates over a −62 to +100-deg C range, accurately controls amplifier gain with respect to time, says **Avionic Div., John Oster Mfg. Co., Dept. S/A, 1 Main St., Racine, Wis.**

The device consists of a 115-V, 400-cycle synchronous motor with phase-shifting capacitor coupled through a 24,000:1 ratio gear train, magnetic clutch and dc power supply, and spring reset mechanism for driving a two-gang potentiometer. The hermetically sealed unit can be built with cams and snap-type switches for accurate cycle timing.

Write in No. 468 on Reader Service Card

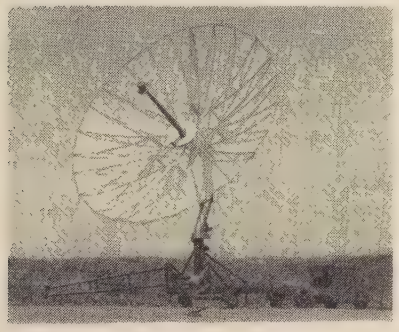
CONTROL SYSTEMS *in standard line*

Standard, pre-engineered, control packages for use on any machine requiring point-to-point positioning of linear or rotary-motion members are offered in a complete line by **General Electric Co., Dept. S/A, Schenectady 5, N. Y.** The numerical positioning systems include one, the Mark V, capable of automatic, simultaneous control of from one to five linear or rotary motions from input data stored on standard one-in wide punched tape or manually-set decade switches.

The Mark I-M is a semi-automatic system for one-motion control from manually-set decade switches.

Write in No. 469 on Reader Service Card

TRACKING ANTENNA *features economy*



A folding 28-ft reflector, hand-operated elevation and azimuth drive system, and a self-contained trailer mount and tower are featured in the Transportable Tracker, a new tracking antenna. The device combines maximum economy with utility, says **D. S. Kennedy & Co., Dept. S/A, Cohasset, Mass.**

Collapsed, the antenna, which uses a cloth reflecting surface, can be towed between locations by a light truck or station wagon. The design permits addition of motors and selsyns for operation of the elevation and azimuth drives.

Write in No. 470 on Reader Service Card

CEMENT *resists fuels*

A fluro-elastomer cement that bonds Vicon rubber to itself or to metals is resistant to fuels and chemicals up to temperatures of 500 deg F, says **The Connecticut Hard Rubber Co., Dept. S/A, 407 East St., New Haven 9, Conn.** COHRlastic C-328 RTV is a two-part system that vulcanizes at ordinary room temperatures.

The cement was originally developed to permit field repair of Viton rubber fuel cells. It is also suggested for lining tanks and similar equipment to prevent chemical corrosion, as well as for potting, patching and sealing applications.

Write in No. 471 on Reader Service Card

more on next page

What can you do with a remarkable instrument like this?

We knew we had an outstanding instrument in our product line when this readout device was introduced several years ago. It proved to be ahead of its time during those early days, but now this remarkable precision instrument for displaying data is gaining acceptance in many industries. It's about as big as a candy bar, and it will display, store, or transfer up to 64 different numbers, letters, or symbols without using complicated conversion equipment and "black boxes."

This is an entirely new species of readout device so we had to give it a new name, the Readall* readout instrument.

We developed the Readall instrument for data display in flight control equipment. We knew the Readall instrument was fine but didn't know just *how* valuable it was. But one of our engineers did. He designed a complete new pipeline control system based on the new instrument. The application was a breakthrough in data handling, and the control system is a big success.

Naturally, we put the Readall instrument on the market so systems engineers could use it to improve their control systems. We announced the Readall instrument as ". . . an electro-mechanical, D.C. operated, readout device for displaying characters in accordance with a pre-determined binary code . . . a compact, self-contained device . . . which can be applied to the output of digital computers, teletype receiving equipment, telemetering systems, or wherever data must be displayed."

Other systems have been developed with separate units for data display, decoding, storing, and electrical readout. These separate units cost more and occupy more room. Market response confirms the need for *one*, *small*, inexpensive unit that does all three jobs. The Readall instrument serves the purpose.

We'd like to discuss possible applications for the Readall instrument with you. If you want information as to possible applications you have in mind for this remarkable instrument, please fill in the coupon.

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DIVISION OF WESTINGHOUSE AIR BRAKE COMPANY
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Union Switch & Signal
Division of Westinghouse Air Brake Company
Pittsburgh 18, Pennsylvania

Here is a possible application we have in mind for the Readall instrument:

_____

_____

☐ Send more information about the Readall instrument

Name _____ Title _____

Company _____

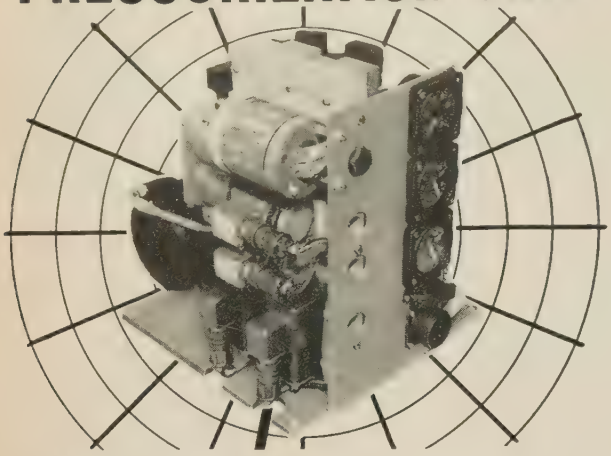
Address _____

City _____ Zone _____ State _____

See us at Eastern Joint Computer Conf. Dec. 1, 2, 3, 1959
Statler Hilton Hotel, Boston, Mass. Booths #1 and #2.

Write in No. 145 on Reader Service Card at start of Product Preview Section

A *NEW* Dependable PRESSURIZATION UNIT



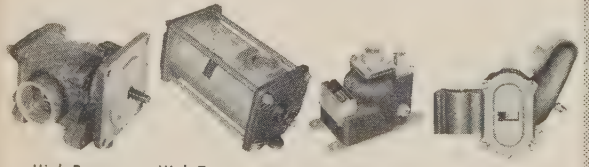
Check these features:

- DRY AIR TO −85°C DEWPOINT. SELF-REACTIVATING
- CONTINUOUS, CLEAN (oil-free) AIR for life
- HIGH and LOW PRESSUE SYSTEM ranging from 15 psia to 80 psia.
- INDICATORS and INTERLOCKS provided for high and low pressure systems.
- HIGH IN PERFORMANCE, LIGHT IN WEIGHT. Suitable for airborne or ground support application.

Exclusive drying method uses two automatic self-reactivating dehydrators. Unit is lubricated and grease packed for a minimum life of 1000 hours. Model 101-018 is representative of a series of "packaged assembly units" consisting of qualified components that have been designed and developed over the years by Great Lakes.

Let us show you how you can save time and money by incorporating existing units in your design plans at an early stage.

Some of the complete line of products designed and manufactured at Great Lakes



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ALTITUDE COMPUTER is very accurate

G forces, vibration, or changes in orientation as encountered in maneuvering flight do not affect the accuracy of this compact, lightweight altitude computing and indicating system, says **General Controls Co., Dept. S/A, 1320 S. Flower St., Burbank, Calif.** The rapid slewing rate provide accurate and instantaneous altitude information throughout the high rates of climb and descent of jets.

Typical accuracy is ±¼ per cent of altitude or 100 ft, whichever is greater, from sea level to 80,000 ft. Click-in-type tens counters are used for easy reading at rates of climb or descent beyond 60,000 ft min. The computer is equipped with an analog-to-digital converter output, and a variety of other output functions of altitude are available. The system weighs 7.5 lbs and the computer measures 4 x 4 x 12 in. The indicator is eight in. long, and 3.25 in. in diameter.

Write in No. 472 on Reader Service Card

BLOWER for ground support

The MSA-10569 cooling blower is being used in complex ground support facilities for calibrating critical aircraft equipment, says **The Torrington Mfg. Co., Dept. S/A, Torrington, Conn.** It will deliver 25 cfm of air against a static pressure of eight-in. of water.

Environmental provisions of MIL-E-5272A apply to the four-lb unit, which has a 115-V, 400-cycle, single phase aircraft motor.

Write in No. 473 on Reader Service Card

MOLYBDENUM SHEET features high ductility

This pure molybdenum metal sheet has far greater ductility than any other commercially available, says **General Electric Co., Dept. S/A, Nela Park, Cleveland 12, O.** The new sheet is expected to simplify many of the processes where molybdenum sheet metalworking is used.

HD sheet can be bent at right angles or double upon itself at room temperature, a feature making it ideal for punching and deep drawing operations. The sheet, which is most useful in thicknesses of 0.025 to 0.125 in., is reported to have less tendency to delaminate or punching, stamping, and shearing than do ordinary commercial grades of molybdenum.

Write in No. 474 on Reader Service Card

CONTROL SYSTEMS in modular packaging

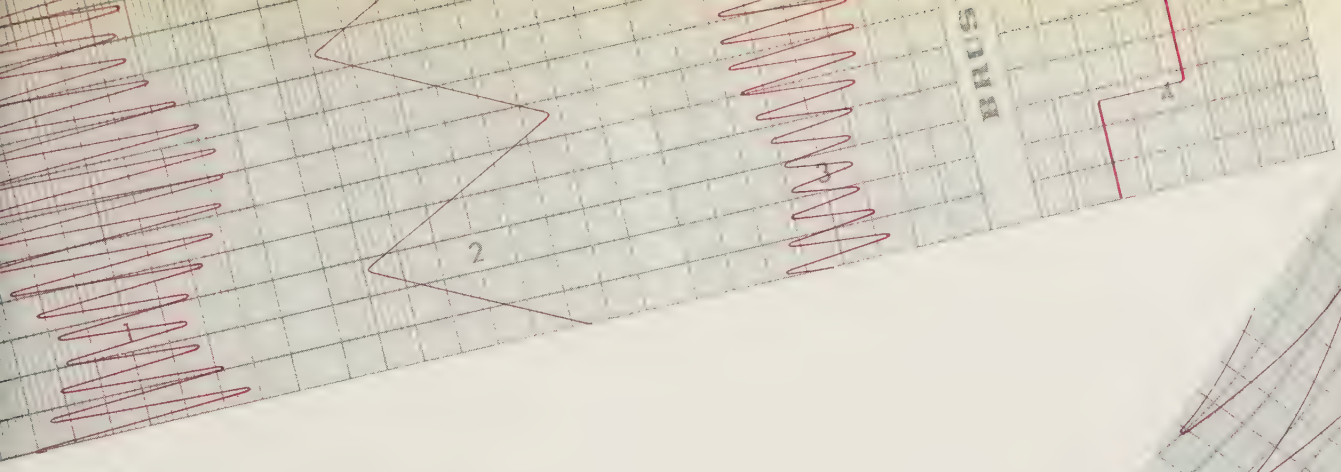
Modular control systems for the aircraft, missile and related fields are being built or assembled entirely from stock units, assemblies and sub-assemblies, says **Airborne Accessories Corp., Dept. S/A, 1414 Chestnut Ave., Hillside 5, N.J.** Engineers may design around the systems or use them, slightly modified, as the basis for immediately accessible systems.

The control systems include transducer (such as potentiometer and temperature probes), power amplifier, linear or rotary actuator, and auxiliary equipment. The amplifier units consist of standardized control boxes into which are plugged transistorized or magnetic pre-amplifier and power amplifier sub-systems. Sub-system circuitry is mounted in a compact chassis and any of the several units can easily be slid in or out of the control box. The amplifiers will drive motors ranging up to 200 W, power linear actuators with maximum operating load capacities up to 500 lbs, and rotary actuators with capacities up to 100 in.-lbs. They can also control any physical response in relation to a variable stimulus.

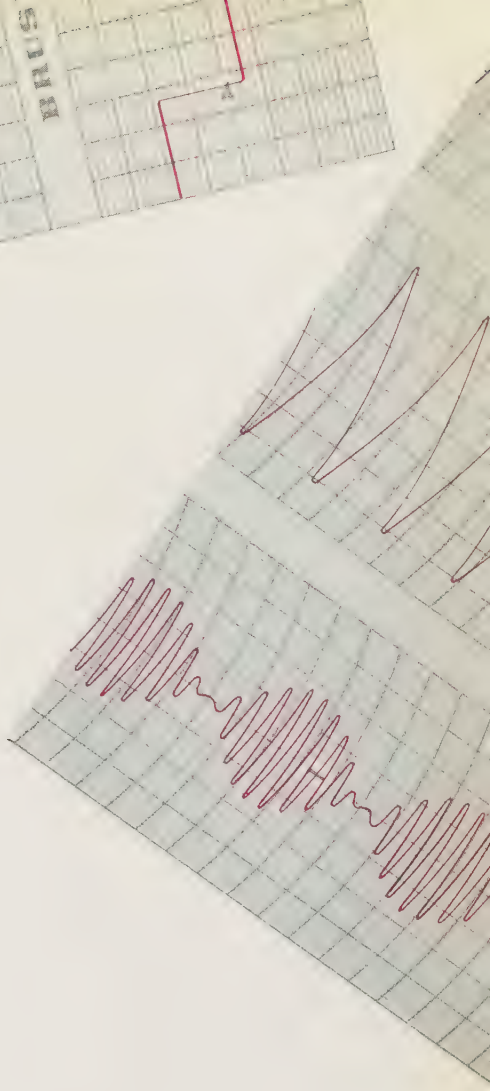
Write in No. 475 on Reader Service Card

more on page 223

Write in No. 147 on Reader Service Card



in chart paper



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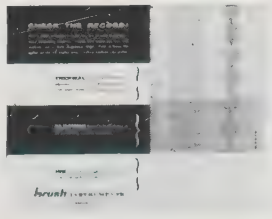
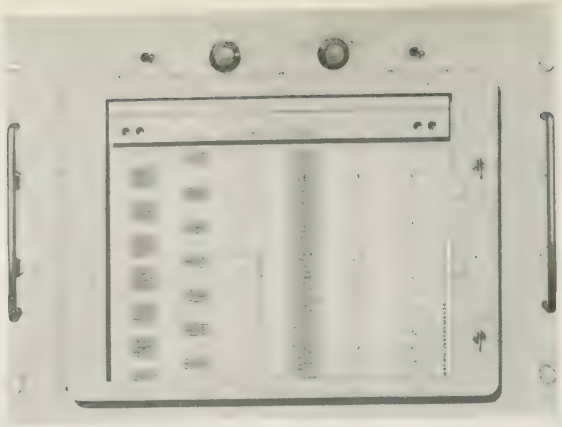
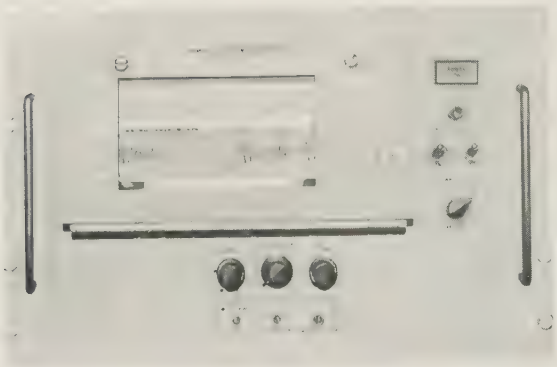
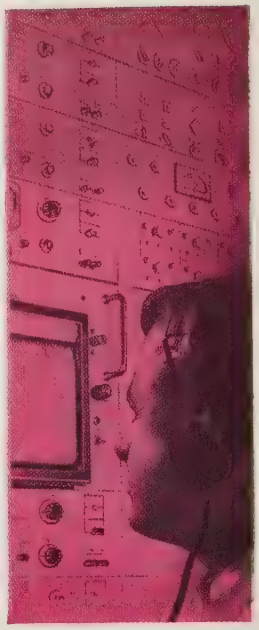
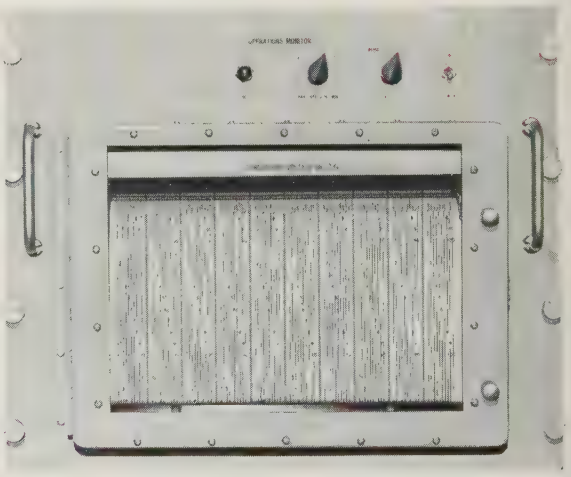


Write for samples of actual tracings on Brush Chart Paper. Ask for "Check the Record".









in direct writing recording systems

only Brush designs specifically for mil specs

From every nut and bolt to the shipping crate, fully militarized Brush Direct Writing Recording Systems are *originally* built to meet military specifications.

That's why they are performing every imaginable task of data acquisition and recording at U. S. and NATO installations throughout the world. These electric writing systems have proved their unexcelled reliability . . . from the Operations Monitor that will record 120 separate operations at the instant they occur . . . to the Analog and Sequence Recorder that simultaneously records both analog data and sequential events. And, they are built for maximum performance in the hands of non-technical personnel.

Brush equipment is already at work putting evaluation data in writing for a whole new generation of weapons. When the weapons become operational, Brush MIL Recorders are a vital part of the system. This experience is unique in the industry. *Before* prototype design becomes a problem—call, write or wire Brush for complete details.

brush INSTRUMENTS

DIVISION OF CLEVITE CORPORATION

37TH AND PERKINS CLEVELAND 14, OHIO

POTENTIOMETER
for printed circuits

The Model 220 Trimpot leadscrew-actuated potentiometer, a subminiature, wirewound unit rated at one W, has been designed for use with printed circuit boards and modular assemblies, says **Bourns, Inc., Dept. S/A, P.O. Box 2112, Riverside, Calif.** The 3/16 x 5/16 x 1-in. units are available in resistance from 100 to 20k ohms, have a 100 per cent usable range, and operate to 175 deg C.

Units are said to meet or exceed government specifications for humidity, shock vibration and acceleration. Available terminal types are 1½-in. gold-plated copperweld wires or six-in. Teflon-insulated stranded leads.

Write in No. 281 on Reader Service Card

BANDPASS FILTER
makes radars compatible

Two or more radar systems operating in the same band will do so with a minimum of interaction, with the help of a new bandpass filter, says **Antran Div., International Electronics Mfg. Co., Dept. S/A, 1000 Connecticut Ave., N.W., Washington 6, D. C.** The device narrows the overall radiated bandwidth of a radar transmitter to an optimum width, and it makes receivers sensitive only to a narrow bandwidth.

Undesirable signals are attenuated and unwanted radiation and spurious energy filtered out. The filter accepts any power that can be handled by a waveguide, and it fits into a standard waveguide junction using existing hardware. The range of frequencies is 200 to 10,000 mc. SWR is 2:1 maximum in bandpass, and insertion loss is less than ½ db.

Write in No. 282 on Reader Service Card

RESIN
withstands high heat

Exposure to temperatures of 600 deg F for hundreds of hours does not affect the strength of this resin, which was developed for use with fibrous glass and asbestos reinforcements to make radomes for supersonic aircraft, according to **Plastics Div., Monsanto Chemical Co., Dept. S/A, Springfield, Mass.** Resinox SC-1013 is a silane modified phenol-formaldehyde resin suggested for high heat applications where plastics are impractical.

The resin is reported to have high-frequency electrical properties and high temperature performance characteristics several times better than conventional phenol-formaldehyde resins.

Write in No. 283 on Reader Service Card

RECTIFIER
is multi-function device

Some of the characteristics of the rectifier and the power transistor are combined in a silicon controlled rectifier useful where blocking voltages to 200 V and load currents to ten amps are required, says **International Rectifier Corp., Dept. S/A, 1521 E. Grand Ave., El Segundo, Calif.** The three-junction semiconductor component is capable of rapidly switching to a conducting state when a signal is applied or when its critical forward breakover voltage is exceeded.

The rectifiers is reported to be capable of performing many of the functions of magnetic amplifiers, thyratrons, ignitrons, power transistors, and other units controlling power to a load proportionally from an ac source. The X10RC 2 through X10RC 20 Series is available with peak inverse voltage ratings of 20, 30, 50, 70, 100, 150, and 200 V. Leakage current in both forward and reverse are about 12 ma. The forward voltage drop in the conducting state is about 1.5 V at 25 deg C. Very rapid firing and recovery times and high temperature operation are other features.

Write in No. 284 on Reader Service Card

more on next page

When it comes to . . .

O-RINGS

Go Goshen

Capitalize on Goshen's experience in serving the needs of hundreds of large and small users of o-rings in the United States and Canada. Precise control of quality thru every stage of formulation and manufacture is the key to an outstanding record of sealing success.

GRC o-rings in all standard AN, MS, SAE and JIC sizes, in many non-standard sizes and in special sizes, are available from established and proven synthetic and silicone specification compounds. Go Goshen for efficient sealing under most any given conditions.

QUALITY ENGINEERED RUBBER PRODUCTS

Ask for your free copy of 16-page O-ring Brochure on size, groove dimensions, compounds and other helpful information.

Goshen Rubber Co., INC.

2412-9 S. TENTH ST. GOSHEN, INDIANA

Write in No. 148 on Reader Service Card

SELECTIVE.PLATING

Production and Repair Plating
without using immersion tanks

Enables You to (1) Precision-plate selected areas economically — without disassembling components; (2) Deposit metals rapidly where conventional electro-plating is impossible or difficult. Mobile equipment takes the process to the job.

Write for Descriptive Brochure.

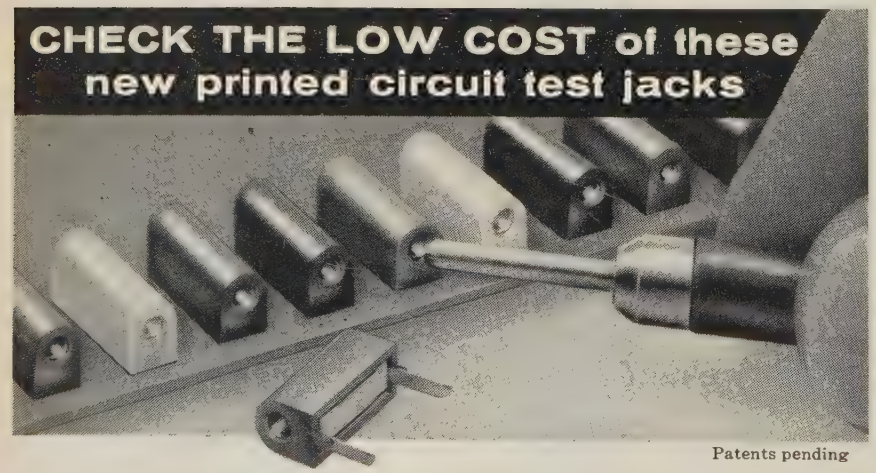
SIFCO METACHEMICAL, INC.
935 East 63 Street • Cleveland 3, Ohio
A Subsidiary of The Steel Improvement & Forge Co.

AGENTS

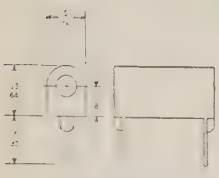
MARLANE DEVELOPMENT CO., INC. 153 East 26th Street New York 10, N.Y.
PIDDINGTON & ASSOCIATES LTD. 3219 East Foothill Blvd. Pasadena, California
OHIO METACHEMICAL, INC. 2742 Second Street Cuyahoga Falls, Ohio
D & S AVIATION CO., LTD. 671 Laurentides Blvd. Pont Viau, Montreal, Quebec

Write in No. 149 on Reader Service Card at start of Product Preview Section

CHECK THE LOW COST of these new printed circuit test jacks



Patents pending



For .052 application holes on .400 centers

Samples on request

Ucinite's new test jack is designed for permanent, soldered assembly to printed circuit boards. Gold-over-silver-plated beryllium copper contacts provide low-resistance contact for repeated insertions of standard .080" diameter test probes. Nylon bodies are available in eleven standard code colors. Uniquely simplified construction affords economical usage in all quantities. Immediate shipments from stock.

ELECTRICAL DOT® ASSEMBLIES

The UCINITE COMPANY
Division of UNITED-CARR Fastener Corporation
Newtonville 60, Massachusetts

Write in No. 150 on Reader Service Card at start of Product Preview Section

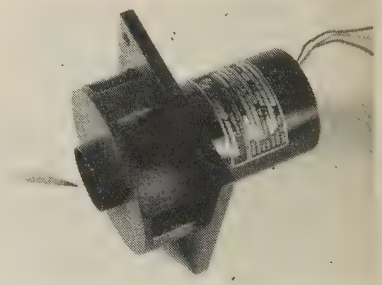
TEST SET for synchro acceptance

This synchro acceptance test set measures electrical error by the proportional-voltage gradient method. Electrical error and fundamental null voltages are measured with a phase-sensitive voltmeter. A 360 deg phase shifter comprises the reference voltage to the phase-sensitive voltmeter, says **Theta Instrument Corp., Dept. S/A, 48 Pine St., East Paterson, N. J.**

In addition, the set features an automatically stepped synchro bridge and automatic selection of test circuitry. It is 24" wide x 25" high x 17" deep.

Write in No. 285 on Reader Service Card

MINIATURE SIREN for missiles



This miniaturized siren is suitable for missile application or other installations requiring miniaturized warning devices. Less than 2" in diameter, the unit produces a tone of 1100 cycles per second at 80 decibels at 11,000 rpm, says **Western Gear Corp., Dept. S/A, 132 W. Colorado Blvd., Pasadena, Calif.**

The siren is powered by a 115 vac 400 cycle motor.

Write in No. 286 on Reader Service Card

DATA READER reduces error

This inexpensive precision Data Reader for the rapid reading of oscillographic type data enables the operator to read an entire time history without readjusting the reader. This reduces the error due to overlay misalignment and zero shift, the result being considerable time saving and accuracies unobtainable using the conventional methods, says **Electro-Kinetics Co., Dept. S/A, Post Office Box 869, Lancaster, Calif.**

The Data Reader is reproduced on a ⅛ in. glass photographic plate; it is dimensionally stable, it holds the record firmly in place while data is being read, and with reasonable care it will be serviceable for several years, it is claimed. The scale can be read accurately to 0.01 in. Price: $35.00 per plate, F.O.B.

Write in No. 287 on Reader Service Card

more on page 228

SIZE 8

SYNCHROS • SERVO MOTORS • MOTOR TACH GENERATORS

400 Cycle: Many for 125°C operation . . . Higher for special applications

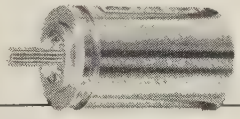
Many Immediately Available From Stock in Small Quantities

SIZE 8 SYNCHROS

Highly Stable. Minimum Error Variation from −55°C to +125°C

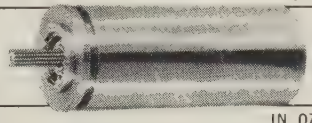
OSTER TYPE	CLASS	INPUT VOLTAGE	INPUT CURRENT AMPS	INPUT WATTS	OUTPUT VOLTAGE	PHASE SHIFT (° LEAD)	ROTOR RESISTANCE (OHM)	STATOR RESISTANCE OHMS	Z_{ro} OHMS	Z_{so} OHMS	Z_{rss} OHMS	NULL VOLTAGE (MV)	MAX. ERROR FROM E.Z. (MIN.)
4253-01*	LZ-CT	11.8	.087	.21	23.5	9.0	157.0	24.0	212+j722	28+j119	263+j69	30	±7
4269-01*	Diff	11.8	.087	.21	11.8	9.0	35.0	24.0	37+j139	28+j124	47+j13	30	±7
4273-01**	XMTR	26.0	.100	.54	11.8	8.5	34.0	12.0	48+j255	12+j45	82+j31	30	±7
4277-01*	HZ-CT	11.8	.030	.073	22.5	8.5	316.0	67.0	500+j1937	79+j350	594+j182	30	±7
4261-01**	Resolver	26.0	.043	.39	11.8	15.0	162.0	22.0	208+j612	34+j159	243+j77	30	±7

*Stator as Primary **Rotor as Primary



SIZE 8 SERVO MOTORS

OSTER TYPE	RATED VOLTAGES	Z = R + jX	IN. OZ. STALL TORQUE	RPM NO LOAD SPEED	WATTS PER PHASE	GM. CM. ROTOR INERTIA	LENGTH IN. MAX.	WEIGHT OZ.	T/I RATIO RAD/SEC²
5004-01	26V 26V	288 = 226 + j 176 294 = 238 + j 174	.15	6200	2.0	.47	0.863	1.2	22,500
5004-02	26V 36V	288 = 226 + j 176 526 = 409 + j 332	.15	6200	2.0	.47	0.863	1.2	22,500
5004-03	26V 40V	288 = 226 + j 176 715 = 582 + j 415	.15	6200	2.0	.47	0.863	1.2	22,500
5004-09	26V 40V	230 = 190 + j 131 519 = 399 + j 332	.20	6200	2.5	.47	0.863	1.2	30,000



SIZE 8 MOTOR TACH-GENERATORS

OSTER TYPE	RATED VOLTAGES	Z = R + jX	IN. OZ. STALL TORQUE	RPM NO LOAD SPEED	WATTS PER PHASE	GM. CM. ROTOR INERTIA	LENGTH IN. MAX.	WEIGHT OZ.	T/I RATIO RAD/SEC²	GENERATOR VOLTAGE	INPUT WATTS	OUTPUT VOLTS PER 1000/RPM
6204-01	26V 40V	230 = 190 + j 131 519 = 399 + j 332	.20	6000	2.5	.65	1.728	2.5	21,800	26	2.5	.25
6204-03	26V 26V	230 = 190 + j 131 230 = 190 + j 131	.20	6000	2.5	.65	1.728	2.5	21,800	26	2.5	.25

Oster®

The Size 8 400 Cycle Servo Motor Tach Generators listed above have 150° max. cont. frame temperature, 110 MA input current, ±5° phase shift and Null Voltage (Total R. M. S.) of 15 millivolts.

OTHER PRODUCTS INCLUDE:

Resolvers
Computers
Indicators
Servo Mechanisms
Servo Torque Units
DC Motors

John Oster MANUFACTURING CO.
Avionic Division
Racine, Wisconsin

EASTERN OFFICE 310 Northern Blvd. • Great Neck, Long Island, New York
Phone: HUnter 7-0030 • TWX Great Neck N.Y. 2980

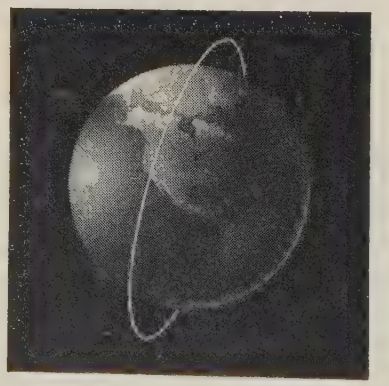
WESTERN OFFICE 5333 South Sepulveda Blvd. • Culver City, California
Phone: EXmont 1-5742 • UPton 0-1134 • TWX S. Mon. 7671

Engineers For Advanced Projects: Interesting, varied work on designing transistor circuits and servo mechanisms.
Contact Mr. Robert Burns, Personnel Manager, in confidence.

Write in No. 151 on Reader Service Card at start of Product Preview Section

Why Lockheed's all-purpose AGENA is America's most versatile satellite

Discoverer Program "Firsts" by AGENA Satellites



First to be put on a polar orbit. Only the Agena, with its horizon-scanner and its response to signals from earth, can be placed on a precise, predicted orbit over the pole.

First to be controlled on orbit. The Agena is also unique in its ability to be turned 180° to a tail-first position and tilted to a 60° downward angle for capsule ejection.

First to carry new systems into space. The Agena has proved out many devices—control, communication, telemetry, life-sustaining—to be used in other advanced space programs.

he Agena is the largest and heaviest true satellite the U.S. has ever put on orbit. It is the only satel-
te that can be put on a precise, predicted orbit...that can be controlled while on orbit...that can
ect a recovery capsule. It can carry a wide variety of very heavy and specialized payloads. The
gena satellite is now used exclusively in the Discoverer Program, directed by the Advanced
esearch Projects Agency and managed by the Ballistic Missile Division of the U.S. Air Force.

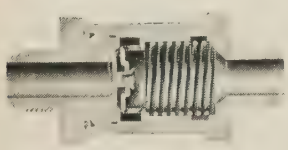
LOCKHEED

MISSILES AND SPACE DIVISION

MISSILE RESEARCH & DEVELOPMENT • BALLISTIC MISSILE SYSTEMS MANAGEMENT
ROCKETRY • ULTRASONIC AERODYNAMICS • SPACE INVESTIGATIONS • NUCLEAR PHYSICS
ADVANCED ELECTRONICS • HIGH-SPEED AUTOMATIC DATA REDUCTION
SATELLITES • RAMJET PROPULSION TESTING

ground support and test equipment

REPUBLIC VALVES

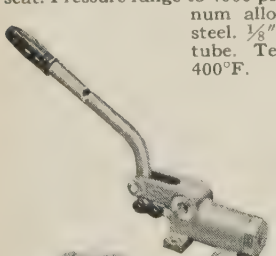


FREE-FLOW CHECK VALVES

No leakage. 3000 psi. Very low pressure drop. Can be furnished to open at ¼ to 35 psi. Brass, stainless steel, or aluminum alloy. ⅛" to 2" pipe or tube. Temp. range -65° to 200°F.

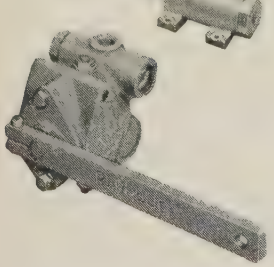
RELIEF VALVES

Quick unloading, smooth operation. Guided shut-off piston with stainless steel or Nylon seat. Pressure range to 4000 psi. Brass, aluminum alloy, or stainless steel. ⅛" to ¾" pipe or tube. Temp. range to 400°F.



HAND PUMP

For hydraulic applications on missile carrier and support equipment. Double-acting. 2 cu. in. displacement per cycle. 1000 psi. working pressure. Aluminum alloy body, stainless steel trim. -65° to 160°F.

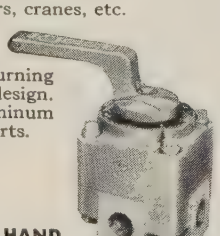


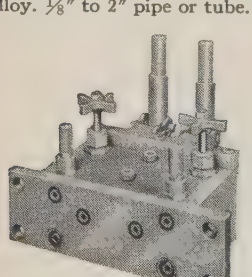
LEVELATOR VALVE

For automatically maintaining height and level condition in any vehicle with air spring suspension. Controls swaying in transit, and off-level position while standing. Applicable to trucks, buses, trailers, carriers, cranes, etc.

LO-TORQ SELECTOR VALVES

Smooth, easy operation, with low turning torque because of pressure balancing design. 0 to 6000 psi. Bronze, steel, or aluminum alloy. ⅛" to 2" pipe or tube. 2, 3, 4 ports.





DUAL HAND PUMP

2 pumps, 2 relief valves, and 2 needle shut-off valves, compactly manifolded for elevating mechanisms, hydraulic applications on ground support equipment, etc. Aluminum alloy body, stainless steel trim. -65° to 160°F.

Distributors in principal cities coast to coast

CHECK RELIEF SELECTOR GLOBE NEEDLE PLUG

RM REPUBLIC MANUFACTURING CO.

15655 BROOKPARK ROAD • CLEVELAND 35, OHIO

Write in No. 152 on Reader Service Card

TRANSMITTING TUBES in complete ine

This line includes 3 low-noise, broad-band travelling-wave, amplifiers, 3 ceramic metal kystrons, two ceramic-metal tetrodes and 4 packaged voltage tuneable magnetrons. The new ceramic-metal-travelling-wave amplifier tubes feature broad band with low noise, high gain, freedom from tuning adjustments, says **General Electric Co., Dept. S/A, Schenectady 5, New York.**

The Klystrons are all designed to operate under extreme conditions of altitude, humidity, temperature, and shock. The ceramic metal tetrodes are designed for use as UHF pulsed amplifiers or oscillators the volltage tuneable magnatrons are high frequency generators of microwave bands. Each unit is aligned at the factory for optimum operation, then permanently sealed to prevent misalignment.

Write in No. 288 on Reader Service Card

ANTENNAS include flush slot type

Two airborne antennas, one (AT-505/AP) a flush slot type for use with radio altimeters, have been reported by **Z & W Mfg. Corp., Dept. S/A, 30240 Lakeland Blvd., Wickliffe, O.** AT-141A/ARC, the second unit, is a sleeve stub type designed for high speeds.

The flush slot antenna can operate at temperatures to 400 deg F, and it maintains a pressure seal within the aircraft. The antenna is used in pairs, one for transmitting and one for receiving, and VSWR is under 2:1 over the 420 to 460-mc range. Termination is a UG/680/U fitting. The sleeve stub type, designed for general purpoe use over the 225 to 400-mc range, consists of a near-quarter wave stub fed through a matching section within the base. It mounts on the aircraft's exterior skin and will withstand pressure resulting from airspeeds up to 600 mph. Radiation is 360 deg.

Write in No. 289 on Reader Service Card

COIL SWITCH is versatile

This coil release switch-light, Part #3701, combines both manual and electrical control for additional versatility, says **Pendar, Inc., Dept. S/A, P.O. Box 3355, Van Nuys, Calif.** Under manual pushbutton operation the switch is a dpdt, double break switch-light combination with an independent lamp circuit.

The unit can also be pushed on manually and then released by a pulse to the coil circuit. The feature permits the use of minimum power for operation. The unit, which can be flush-mounted to the panel, is reported to be ideal for electrically interlocked circuits, where fail-safe features are required. Contacts are rated at five amps resistive at 28 V dc, and operating pressure is three lbs.

Write in No. 290 on Reader Service Card

TACHOMETERS have in-line readout

The ten models in the 1300 Series of electronic tachometers and frequency counters offer a selection of remote indication, explosive-proof installation, self-contained and dual readout types, says **I-L-S Instrument Div., The Meriam Instrument Co., Dept. S/A, 4561 W. 160th St., Cleveland 35, O.** The units use an in-line Nixie numerical readout.

Time bases have fixed selectable times of 0.1, 0.5 and one sec. A count-down time base, crystal and tuning fork standards, and preset variable time bases are features. Input is five to 150,000 cps for sine waves and zero to 150,000 cps for pulses. Accuracy is plus or minus one count, and display time is adjustable from 0.1 to ten sec. Reset of the modular units may be automatic or manual.

Write in No. 291 on Reader Service Card

more on page 230

Materials Memo

3M reports on reinforced plastics . . . advances in printed circuitry . . . super-thin ceramics

REINFORCED PLASTICS TAKE OVER: Early applications of reinforced plastics for missiles involved the forward end of the bird—radomes, nose cones, and data capsules. Constant development of material properties and fabrication techniques led to superior physical characteristics that now make r/p useful in the aft ends also. Reinforced plastic fins, exhaust nozzles, and motor cases are under intensive investigation today. Our subsidiary, ZENITH PLASTICS, working with 3M-developed "Scotchply", has opened a new realm of structural properties for missile designers. Currently available are rocket cases, with strengths of 110,000 psi. Since reinforced plastics have a density of 0.070 lbs./cu. in., this gives a strength density ratio of 1,570,000 inches. To match this, an alloy steel would have to have *a yield strength of 450,000 psi.* In addition, r/p elements offer simplified tooling and eliminate subsequent heat treating operations. For example, the photo above shows a recent Zenith-built tube 57″ in diameter by 26-feet long with critical tolerances. Tooling, consisting mainly of a suitable mandrel, was obtained in just a few weeks.

If you have weight and structural strength problems, drop us a line. We'll arrange to have a Zenith technical representative show you how their reinforced plastic technology can help you solve them.

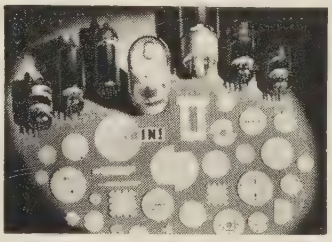
CIRCUITOUS CIRCUITS YOUR PROBLEM? "Making ends meet" with 3M's new CuFlex printed circuitry materials is no strain at all. So flexible are these copper clad laminates that even outright creases are possible without destroying the effectiveness of the circuit. What's more, an exceptionally strong bond between the copper foil and the backing film eliminates worry about delamination of your finished circuit, even if it receives rough handling during assembly. And hand-soldering of CuFlex circuits to other components is a breeze.

CuFlex LAMICOID, to use its full name, consists of a one-ounce electro-deposited copper foil securely laminated to polyester film, Teflon* film, or Teflon* glass cloth constructions. The copper used has 99.5% purity to assure you of fast etching and clean lines with a minimum of shorts and arc-overs in actual use. The polyester backed CuFlex offers an extended useful temperature range of from −65° to 130°C. The PTFE variety extends this range to 200°C for Class H applications with even lower dielectric losses at high frequencies. Both polyester and Teflon* CuFlex are available in thicknesses as low as 0.005″.

For automated circuit production, polyester CuFlex is made in continuous lengths and can be supplied in full 36″ width sheets or slit into tape as narrow as ½″. Teflon* CuFlex is available in sheets 17″ x 37″. For rigid printed circuits, there is a CuClad line of copper bonded to rigid Teflon* glass laminate. We are also experimenting with CuFlex products coated with pressure-sensitive adhesives and would be glad to discuss these with you.

Our MICA INSULATOR DIVISION is quite proud of the fact that CuFlex and CuClad have been selected for the critical circuitry of the brains in several of our most sophisticated missile systems. Let them tell you how CuFlex may fit into your programs as well. Or contact: *Missile Industry Liaison* at the address below.

SLICING IT PRETTY THIN: While we wouldn't recommend reading your morning paper through them, ceramic parts so thin they're semi-transparent are now being produced in volume by our subsidiary, AMERICAN LAVA CORPORATION. By polishing up on their already precision techniques, they've achieved thicknesses (or thinnesses?) as low as 0.005″ without any sacrifice in dimensional uniformity. In the event this figure doesn't raise your eyebrows, we might mention that less than 3 years ago, announcement of parts 0.009″ thin amazed the industry. The material used is a vitrified, vacuum tight AlSiMag alumina. In election tube applications alone, these ultra-thin ceramics offer a myriad of advantages. For example, they . . .



1. Withstand higher de-gassing temperatures.
2. Extend operating temperature range of the completed tube.
3. Reduce damage from fatigue failure and heat deterioration.
4. Eliminate emission losses normally associated with high temperatures, shock, and vibration.

We're sure you'll find it easy to extend this list substantially when you consider that these unique alumina ceramics have also been found highly satisfactory for use as micro-wave windows, transistor platforms, insulators for hearing aids, in digital counter tubes, radio crystal cages, Tinker Toys for high temperature amplifiers, high temperature relays, transformers, fuses, and innumerable other high temperature devices. We predict it won't be long before they find broad application in high temperature printed circuits as well.

While you're checking with your local American Lava representative on these thin ceramics, you may care to discuss with them others of their activities in the field of precision ceramics. American Lava Corporation has many types of Technical Ceramic Compositions, and are considering adding new ones. If they're not already producing exactly what you need in ceramic, the chances are pretty good that they can.

—FOR MORE INFORMATION...CLIP and MAIL today!—

Missile Industry Liaison, Dept. VAA-129
3M Co., 900 Bush Avenue, St. Paul 6, Minn.

Please send information on items checked:

- ☐ Reinforced Plastics
- ☐ Ultra-Thin Ceramics
- ☐ CuFlex Printed Circuit Material
- ☐ 3M Products and Capabilities for the Missile Industry

Name_____

Position_____

Company_____

Address_____

City_____ Zone_____ State_____

*DU PONT CO. TRADEMARK

"SCOTCHPLY," "CUFLEX LAMICOLD," "CUCLAD," "IRVINGTON" AND "AL SI MAG" ARE REGISTERED TRADEMARKS OF 3M CO.

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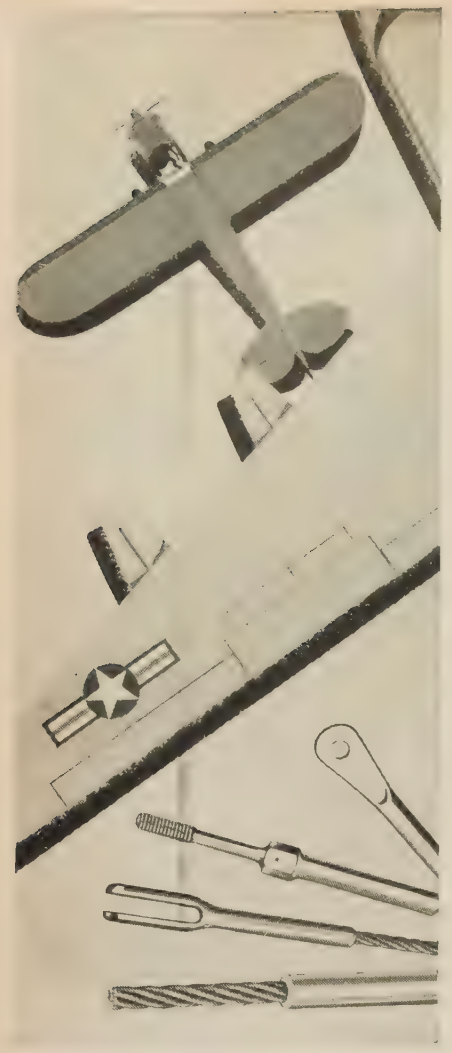
. . . WHERE RESEARCH IS THE KEY TO TOMORROW

3M COMPANY

MISSILE INDUSTRY LIAISON 1



ROEBLING AIRCORD
comes to you highly recommended

It is made to exceed *military* specifications. You have a choice of tinned, galvanized or stainless Roebling Aircord. You can also select from a full range of sizes and constructions—including Lock-Clad — the preformed cable with aluminum tubing swaged around it.

Cord can be furnished in stock lengths or in complete assemblies... fittings are available for every requirement.

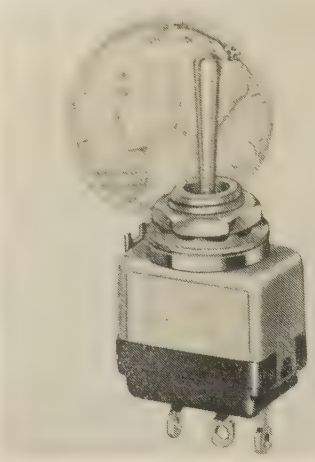
Air-supply houses, manufacturers—*anyone* interested in full details of Roebling Aircord may address themselves to Wire Rope Division, John A. Roebling's Sons Corporation, Trenton 2, New Jersey.

ROEBLING

Branch Offices in Principal Cities
Subsidiary of The Colorado Fuel and Iron Corporation

Write in No. 154 on Reader Service Card

TOGGLE SWITCHES are very small

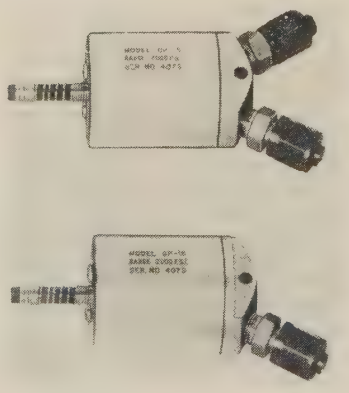


These one- and two-pole military toggle switches, no bigger than a dime, have been designed for aircraft, missile and electronic applications, according to **Cutler-Hammer, Inc., Dept. S/A, 204 N. 12th St., Milwaukee, Wisc.** Contacts are gold-plated and a wiping action insures good contact even on low energy circuits.

Switch action may be maintained or momentary, and high toggle lever operating forces are featured. The insulating material used provides excellent arc-tracking resistance and recovery voltage.

Write in No. 292 on Reader Service Card

TRANSDUCERS for high ranges



These high performance, high range miniaturized pressure transducers, Model GP-15D, is said to be highly resistant to mechanical shock and vibration, according to **Borg Warner Corp., Dept. S/A 3300 Newport Blvd., Santa Ana, Calif.** Ranges extend from 10 psig to 6,000 psig.

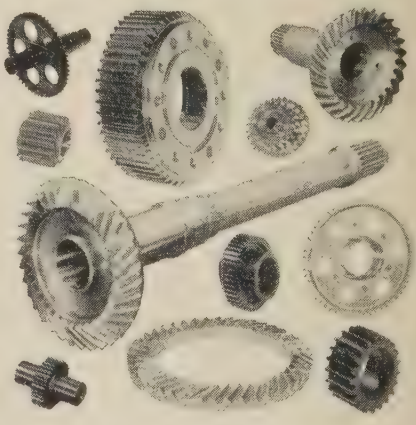
The unit is designed to convert pneumatic or hydraulic pressure into a proportional electric signal for measurement under both static and dynamic conditions.

Write in No. 293 on Reader Service Card

more on page 232

AIRCRAFT QUALITY

GEARS



The precision meshing of gear teeth in aircraft is the expected—but the precise meshing of Fenn facilities and personnel to meet rigid or unusual gear requirements is welcomed . . . and often unexpected. Fenn not only offers you ultra-modern gear tooth facilities (spiral bevel, too) and highly skilled personnel —but a willingness to tackle the tough ones shoulder to shoulder from engineering to final inspection. The Fenn Manufacturing Co., Newington, Conn.

Perhaps you would like to take a look at Fenn through our Facilities Folder. Write today for copy!

FENN

Precision Gears That Fly

Write in No. 155 on Reader Service Card

A Seaslug test vehicle being fired. In missiles of this type the Armstrong Whitworth IPN Gas Generator has been tested and proved under actual flight conditions.

IPN* revolutionises missile power supplies

Details of the new Armstrong Whitworth Gas Generator

Many liquid fuels have been tried as possible solutions to the auxiliary power problems of missiles, but not till Armstrong Whitworth developed the use of Isopropyl Nitrate was there any which could be pronounced an unqualified success. The result of Armstrong Whitworth work, the Type TP-1 Gas Generator, has been tested under flight conditions, where it proved entirely satisfactory. The advantages of the T.P.-1 Gas Generator are :

No fuel waste. The IPN generator can vary the amount of fuel burnt so that it supplies only the exact amount of gas required by the machinery at any given time. This gives it a distinct advantage over solid fuel systems, which all the time supply enough to meet the maximum demand (probably made only 5% of the time).

Light weight. Because of its fuel economy, the IPN generator carries no excess weight.

Compactness. IPN is stored in tanks built into the generators — unlike high-pressure gas which needs bulky bottles.

Unaffected by atmosphere. Ram-air systems are limited to the lower atmosphere, solid fuel varies its burning rate according to the surrounding temperature. With IPN there are no such problems.

Ease of storage. The IPN generator can be stored fully loaded for two years and needs no maintenance or topping up.

Safety. IPN cannot be detonated by shock, and needs no other precautions than those normally taken with inflammable fluids.

Isopropyl-Nitrate *

THE ARMSTRONG WHITWORTH IPN GAS GENERATOR

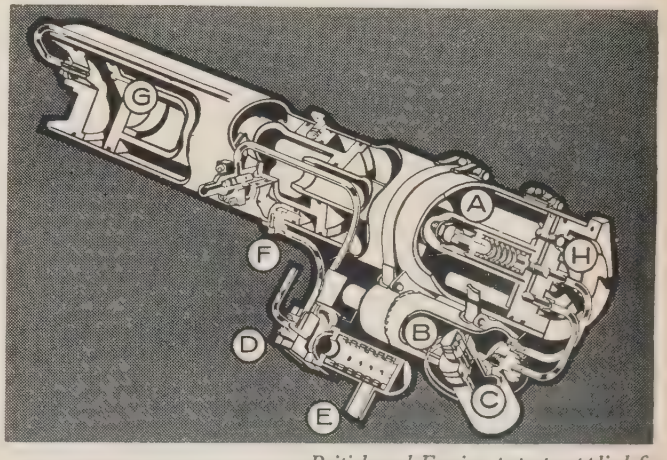
Type illustrated measures 29.8″ x 5.5″ x 10.3″

IPN from fuel store (A) enters combustion chamber (B) is ignited by cordite charge (C).

At (D) hot gas joins atomised coolant. Most of resultant mixture goes to operate power supplies machinery, via supply line (E). Some, however, is tapped off through pipes (F) to drive pistons (G) which expel fuel and coolant, so making the system self-sustaining.

Gas tapped off from combustion chamber operates fuel control valve (H), which limits supply of fuel to exact amount required by machinery.

Armstrong Whitworth can tailormake IPN units to customers' own specifications, and will always be glad to advise on technical problems.



British and Foreign patents applied for

For further information please write to :—

SIR W. G. ARMSTRONG WHITWORTH AIRCRAFT LTD., Baginton, Coventry, England

A MEMBER OF HAWKER SIDDELEY AVIATION—32 DUKE STREET, ST. JAMES'S, LONDON, ENGLAND

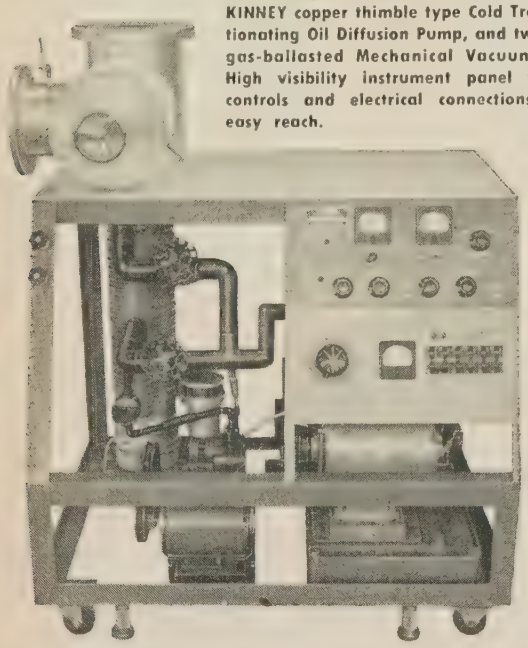
Write in No. 156 on Reader Service Card at start of Product Preview Section

VACUUM

Kinney®

HIGH PERFORMANCE PACKAGED PUMPING SYSTEMS

Built in Models 200, 400 and 600, KINNEY PW Packaged Pumping Systems consist of a KINNEY copper thimble type Cold Trap, Fractionating Oil Diffusion Pump, and two-stage, gas-ballasted Mechanical Vacuum Pump. High visibility instrument panel with all controls and electrical connections within easy reach.



Get the greater utility and versatility built into these KINNEY PW Series High Vacuum Pumping Systems which users call "the workhorses of the modern laboratory." These units will evacuate altitude chambers, tanks, furnaces, ovens, tubes, bell jars or other laboratory equipment, attaining pressures in the order of 5×10^{-6} mm Hg. without coolant in the cold trap and substantially lower when coolant is used.

These units are mounted on casters so that they can be moved readily to serve a variety of facilities, especially those which are fixed installations. A unique and exclusive High Vacuum Valve design enables the operator to rotate the Valve and position the suction connection horizontally, vertically, or at any angle in between. Thus, it is possible with a base plate assembly to quickly convert to an Evaporator.

Bring your file of new developments in High Vacuum up-to-date. Write today.

KINNEY MFG. DIVISION
THE NEW YORK AIR BRAKE COMPANY
3528M WASHINGTON STREET • BOSTON 30 • MASS

Please send me Bulletin 4000.1 ☐ I am also interested in Mechanical Pumps ☐ Oil Diffusion Pumps ☐ Vacuum Furnaces ☐ Evaporators ☐

Name_____

Company_____

Address_____

City_____ Zone_____ State_____

Write in No. 157 on Reader Service Card

COMMUTATOR for FM/FM systems

A new, four-pole telemetering commutator suitable for FM/FM systems in missile environments combines the flexibility of two separate two-pole switches in one case because of its pole arrangements, says **Instrument Development Laboratories, Inc., Dept. S/A, 67 Mechanic St., Attleboro, Mass.** Two poles have 30 contacts each and the other two, 60 each: all contacts are make before break.

All 180 data channels are available at hermetically-sealed connectors, permitting external wiring for sequencing. Cross-strapping a number of data channels per pole results in higher sampling rates. The 6½-in. long, three-lb device has a 28 V dc motor drive and is designed to keep radio noise interference from the data channels. Life expectancy exceeds 250 hrs.

Write in No. 294 on Reader Service Card

TACH GENERATOR is temperature-compensated

A Size 15 motor tach generator suitable for transistorized operation is offered in a temperature-compensated design by **Avionic Div., John Oster Mfg. Co., Dept. S/A, 1 Main St., Racine, Wis.** Maximum variation in output voltage is ±0.2 per cent over an ambient temperature range of −10 to +95 deg C.

The Type 6280-05 four-pole, 115-V, fixed phase motor has a 36-V control phase center tapped winding. It is rated for a no-load speed of 9500 rpm. The output voltage gradient is 2.2 V per 1000 rpm, and linearity is .05 per cent up to 4200 rpm.

Write in No. 295 on Reader Service Card

SILICONE RUBBERS have wide application

Compounds that show excellent resistance to jet fuels, solvents and hydraulic oils are among those that can be formulated from a series of silicone rubber materials developed by **Dow Corning Corp., Dept. S/A, Midland, Mich.**

Molding, extruding, calendering and dispersion techniques may be employed. Among the masterbatch materials are Silastic LS-422 Base and 433 Base, both of which can be used in the formulation of compounds with up to 80 durometer. LS-422 is a fluorosilicone rubber that is fuel, oil and solvent resistant. Silastic 433 is a silicone polymer useful for compounding stocks that process easily and efficiently. Silastic LS.63U is another fluorosilicone rubber that is useful in the missile and aircraft fields. It is serviceable at both very high and very low temperatures, and it exhibits very low volume swell and little physical property change when immersed in jet fuels and hydraulic oils. It is suggested for the manufacture of seals and gaskets. Silastic 52 and Silastic 82, of 50 and 80 durometer, respectively, can be blended to obtain any intermediate hardness.

Write in No. 296 on Reader Service Card

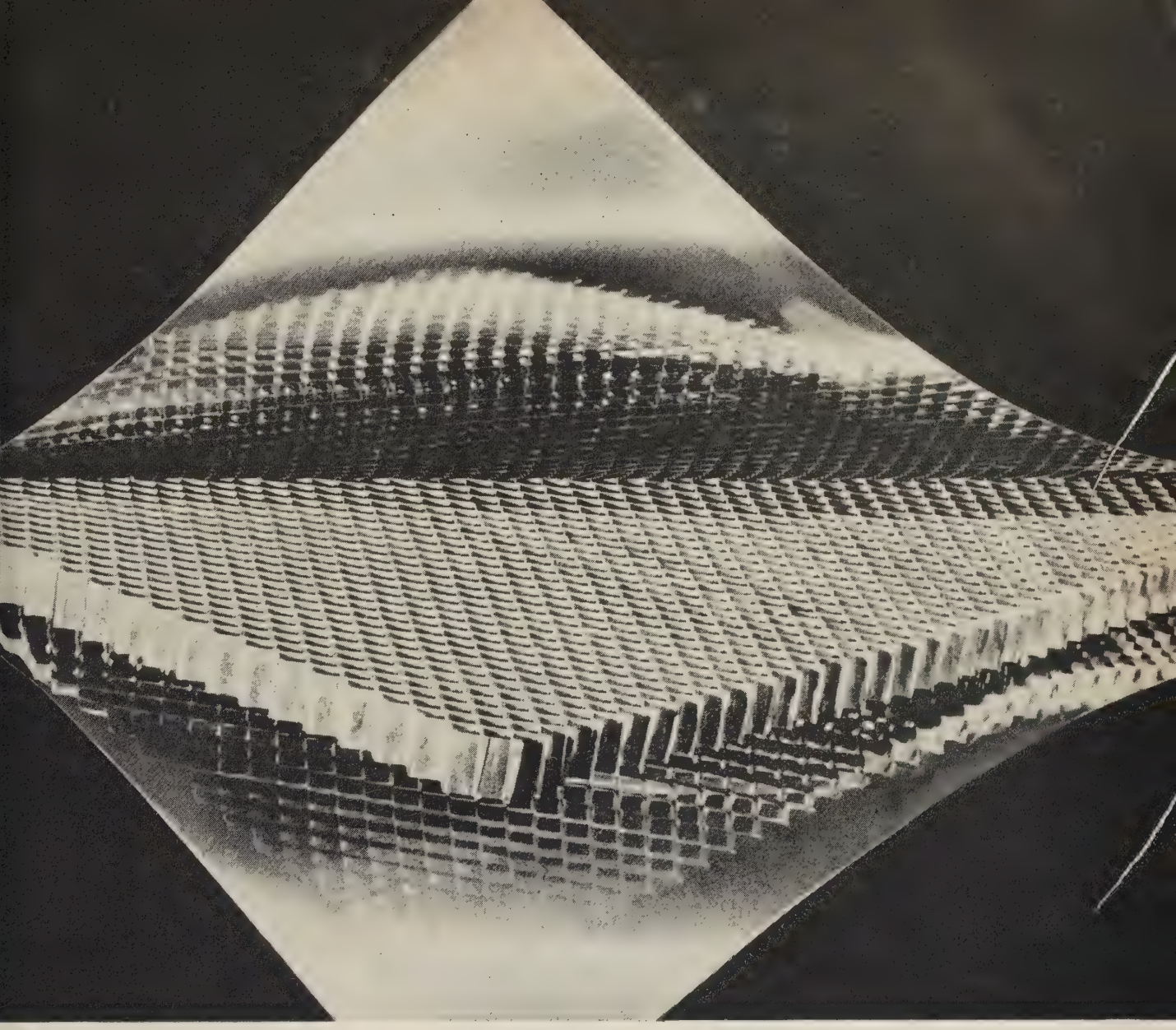
MOTOR for flyaway hoists

This compact ac motor for flyaway hoist application, known as model 693, meets MIL-M-7969B, is reversible and features a quick stopping magnetic brake and torque limiting clutch. Nominal force delivered at the drive shaft is 5 inch-lbs at 7200 rpm, says **U. S. Industries, Inc., Dept. S/A, Santa Barbara, Calif.** Designed for 200v, 3-phase, 400 cyc systems, the motor is 4 in in diameter and weighs 7.5 lbs.

Thermal protection, including automatic reset, is provided to prevent burnout. During an overload condition, no part of the motor exceeds 390 deg F when operating at normal ambient temperatures.

Write in No. 297 on Reader Service Card

more on page 234



More mileage from Argon in Honeycomb brazing

You can learn a lot about using argon efficiently from the people who make it—Linde Company. This gas is well established as the best atmosphere for honeycomb brazing. Yet some fabricators may be using far greater volumes than they actually need.

This is where LINDE can help in reducing costs. LINDE's "three-phase" concept of argon application includes:

Providing a ready supply of gas to the specifications you require;

Maintaining purity during distribution within your plant;

Getting maximum results from the argon used.

LINDE is uniquely qualified to perform this service because of its extensive work with honeycomb fabricators... and its experience in the production, handling and storage of industrial gases. For aid in the use of argon atmospheres, write Dept. SN-12, Linde Company, Division of Union Carbide Corporation, 30 East 42nd Street, New York 17, N. Y. *In Canada:* Linde Company, Division of Union Carbide Canada Limited.

Linde

UNION CARBIDE

"Linde" and "Union Carbide" are registered trade marks of Union Carbide Corporation.

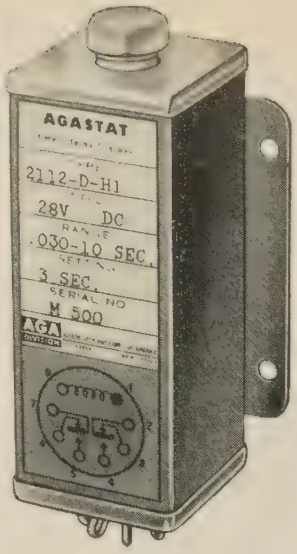
Write in No. 158 on Reader Service Card at start of Product Preview Section

NOW!

MINIATURE AGASTAT®

time/delay/relay

MEASURES ONLY 4"x1½"x1½"



The Miniature Agastat time delay relay is a space-saving answer to aircraft, missile and computer problems. You get all these valuable features in one small package:

- Easily adjusted timing ranges as short as .030 seconds.
- Repeat accuracy of ± 5%.
- Time delay on energizing or de-energizing.
- For DC or AC operation.
- Hermetically sealed or dust-proof housings.

Write today for the full details on the new miniature Agastat. Dept. A36-1219.

AGA DIVISION — ELASTIC STOP NUT CORPORATION OF AMERICA
1027 Newark Avenue, Elizabeth, N. J.

Gasaccumulator Co., (Canada) Ltd., 12 Gower Street, Toronto 16, Ontario

Write in No. 159 on Reader Service Card at Start of Product Preview Section

for control cable or aircraft tiedown systems use . . .

Wickwire Aircraft Control Cables and Wickwire Rope for aircraft tiedown systems are sold through

AIR ASSOCIATES

warehouses at:
Atlanta, Ga. • Chicago, Ill. • Columbus, Ohio
Dallas, Tex. • Los Angeles, Calif. • Miami, Fla.
San Francisco, Calif. • Teterboro, N. J.
Also these warehouses operated by Standard Products, Inc. (a wholly-owned subsidiary):
Kansas City, Kan. • Tulsa, Okla. • Wichita, Kan.

For your ordering convenience and quick-delivery needs, Air Associates maintains large stocks of Wickwire Wire Rope in warehouses located at or near airports.

For the best in quality *and* service, order Wickwire Rope through the nearest Air Associates warehouse.

6932A

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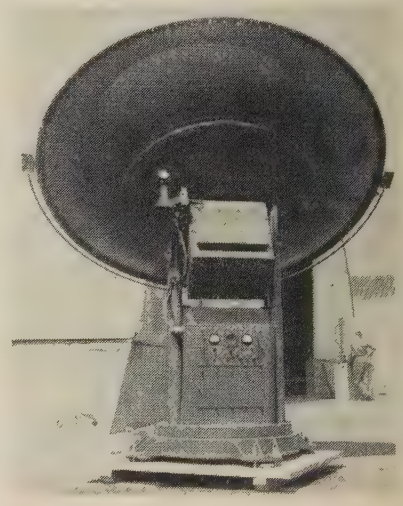
NETWORK for interference testing

Either of these power line impedance stabilization networks, when inserted in an ac/dc line, presents a definite RF impedance to the interference-producing equipment and to the power source. The units thus make possible accurate and repeatable interference acceptance tests in conjuntion with radio-interference measuring equipment according to **Stoddart Aircraft Radio Co., Inc., Dept. S/A, 6644 Santa Monica Blvd., Hollywood 38, Calif.**

The 50-amp type, Model 9122-1, is approved in accordance with MIL-I-26600 (USAF), and both it and the 100-amp unit, Model 91222-1, are approved in accordance with USAF, BuShips and FCC regulations.

Write in No. 298 on Reader Service Card

PEDESTAL for tracking systems



A rugged, steerable pedestal unit designed for diverse types of antenna systems is capable of high accuracy, fast response, high acceleration and quick reversibility in scanning and tracking operations, says **Servo Corp. of America, Dept. S/A, New Hyde Park, Long Island, N.Y.** Modified, the mount may also be used for various systems, including tracking, control and telemetering of missiles and drones; satellite tracking, receiving, and transmitting; and transmitting to, and receiving from, relay station balloons for over-the-horizon, line-of-sight telemetering applications.

The mount's unusual accuracy stems from the push-pull arrangement of its clutch-type servos, which provide control circuits with high natural frequencies, as well as response speeds that are practically instantaneous. The elimination of wear and backlash is the result of the hysteresis-effect clutches and the double gear train arrangements, respectively.

Write in No. 299 on Reader Service Card

more on page 236

NEW VICKERS® Packaged Valve Assembly accelerates – decelerates Thor Missile Erector smoothly without ratcheting.

Operating Pressure	3400 P.S.I.
Proof Pressure	4500 P.S.I.
Burst Pressure	7500 P.S.I.
Temperature Operating Range	−65°F to +150°F
Filtration Nominal	10 Micron

Smooth control of the Thor erecting cylinder is accomplished by a new Vickers' packaged valve assembly. This assembly provides regulated acceleration-deceleration throughout the erecting cycle without compounding structural vibrations. Despite varying external loads and temperatures, firm positive control is maintained as the missile's center of gravity passes over the pivot point.

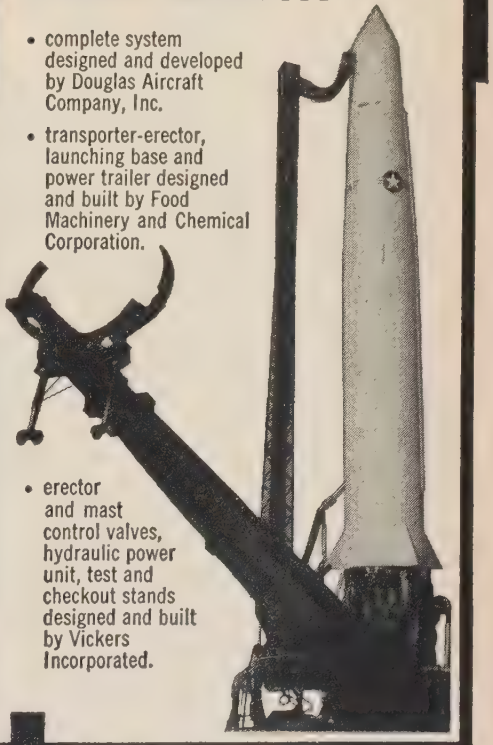
This "system engineered" valve is another example of the special ability of the Vickers Marine and Ordnance Department to solve difficult ground support problems. An integrated package, this new valve consists of a metering-type, modulating flow control that is pressure compensated for a fixed pressure differential. An integral, motor-actuated, 4-way directional control regulates starts and stops in mid-cycle.

Now in production, this valve can be used to control a broad range of accelerations, decelerations and overrunning loads merely by varying combinations of orifice sizes and spool configurations. Horsepower input can be adjusted to meet onsite power availability. Valve output can be controlled electrically, mechanically or hydraulically. Mounting flexibility permits valve installation directly on the hydraulic cylinder.

All units are factory pre-tested, interchangeable and require no external lines except to pump and tank. They are built to meet the most demanding reliability requirements.

THOR missile on launch base...

- complete system designed and developed by Douglas Aircraft Company, Inc.
- transporter-erector, launching base and power trailer designed and built by Food Machinery and Chemical Corporation.



- erector and mast control valves, hydraulic power unit, test and checkout stands designed and built by Vickers Incorporated.

If this valve offers a solution to your problems, call Waterbury, Connecticut, PLaza 6-3684 (TWX: WBY 160) for more complete information. Write for a free copy of Bulletin 5303 "Vickers Oil Hydraulics for Missile Systems."

VICKERS INCORPORATED
DIVISION OF SPERRY RAND CORPORATION
Marine and Ordnance Department
WATERBURY 20, CONNECTICUT

Hydraulic Products for Marine and Ground Defense Applications

MO-219

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Write in No. 172 on Reader Service Card at start of Product Preview Section

BRISTOL

chopper meets reliability standards of Army "Hawk"

PHOTO COURTESY OF RAYTHEON COMPANY WALTHAM, MASS.

Every part that goes into a modern-day missile system must pass a rigid battery of tests and a thorough statistical screening to insure highest possible reliability in action.

That's why we're pleased to announce that Bristol Syncroverter choppers play an important role in guidance of the U.S. Army HAWK missile, produced by Raytheon Company, Waltham, Mass., prime contractor for the complete HAWK weapons system.

Billions of operations. Bristol Syncroverter* choppers are ideal for applications requiring the utmost in statistical reliability. The Bristol life-test lab has now had miniature Syncroverter choppers running for years without failure—both with and without contact load. Just one sample: five choppers with 400-cycle drive and 12v, 1ma, resistive contact load have completed 26,000 hours (2.96 years) continuous operation—over 37-billion operations!

actual size

An extremely wide variety of standard models is available—including external coil low-noise types. For complete data, write: Aeronautical Components Division, The Bristol Company, 150 Bristol Road, Waterbury 20, Conn.

*T. M. REG. U. S. PAT. OFF. 9.26

BRISTOL FINE PRECISION INSTRUMENTS FOR OVER SEVENTY YEARS

Write in No. 162 on Reader Service Card

GEAR MOTOR *for tape, camera*

This 24v dc centrifugally governed controlled 3-speed gear motor is rated at .1 hp at 1920, 1440 and 960 rpm with ±1 per cent variation. It is totally enclosed explosion proof, designed for 500 hour life and built to meet the latest military specifications for camera and tape applications, says **Western Gear Corp., Electro Products Div., Dept. S/A, 132 W. Colorado St., Pasadena, Calif.**

The motor is adaptable to a range of speeds in accordance with customer specified requirements. It measures 6½ in long by 2 5/16 in in diameter.

Write in No. 300 on Reader Service Card

CAPACITORS *made of ceramic*

This new non-inductive capacitor is a ceramic device that reduces mounting area, cost, and installation time, and is suitable for printed circuitry and dip soldering techniques. It is expected eventually to replace most paper capacitors in the .01 and .25 mf range, and mica capacitors in no-drift capacities of 300 mmf to .01 mf, says **Packard Bell Electronics Corp., Dept. S/A, 12333 W. Olympic Blvd., Los Angeles 64, Calif.**

Extruded and molded types are made, and both are suitable for high-temperature use. The extruded model is designed for duty as a structural core and as a surface area to increase capacitance. A no-drift capacitor can be made for values of NPO up to N6000 for temperature compensation. The units have an indefinite life since they contain no active elements.

Write in No. 301 on Reader Service Card

SERVO AMPLIFIERS *for high temperatures*

Three transistorized, potted amplifiers, which provide outputs of 3.5, six and 12 W, have been designed with an operating temperature range of —55 to +125 deg C. says **Bulova Research & Development Laboratories, Inc., Dept. SA, Woodside, N. Y.** The units have a pre-amplifier, driver, and push-pull output stage, and they offer maximum design flexibility in any number of servo systems.

All three use 400 cps and 28 V dc, and voltage gain is fixed at 1500 for the six-W unit and at 1000 for the others. Output signals for all three amplifiers are 40 V rms. Impedances are 10,000, 25,000 and 50,000 ohms, resistive, for the 3.5-, six- and 12-W units, respectively. The Amp-576, the smallest unit, is a one-in. cube in size, the Amp-424-6 (six W) and the Amp-424-12 (12 W) are both 1 7/16 x 1 7/8 x 2 in. high.

Write in No. 302 on Reader Service Card

GAS REGULATORS *for high pressures*

The GD100 and GD200 Series of Gas-O-Dome regulators operate at maximum inlet and outlet pressures up to 6000 psi, have a 12,000-psi proof pressure, and operate over a range of —67 to +250 deg F. The units are designed primarily for high flow regulation of non-corrosive gases and liquids used in missiles and elsewhere, says **Victor Equipment Co., Dept. S/A, 844 Folsom St., San Francisco 7, Calif.**

The GD100 group, which offers a 20,000-scfm maximum flow, is available with valve and orifice sizes from ⅜ to ¾ in. Outlet pressures rise one to 4.5 psi per 100 psi of inlet decay. Maximum flow of the GD200 Series regulator is 50,000 scfm. It has a 1½-in. orifice and holds constant outlet pressure as inlet pressure decays. Connections are available for 3600 or 6000-psi use.

Write in No. 303 on Reader Service Card

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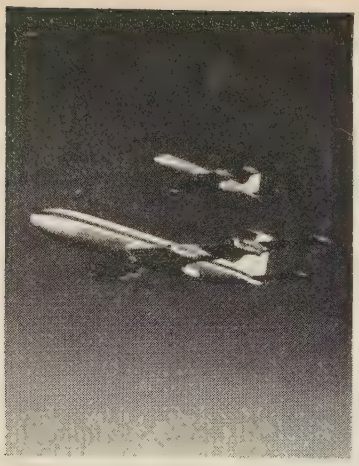
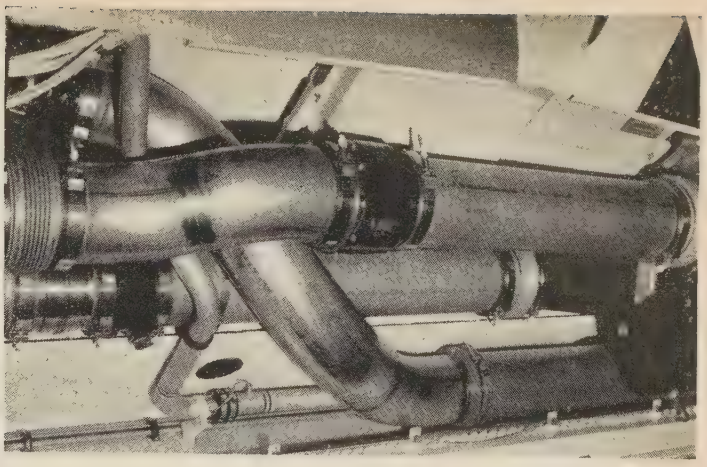




170 *couplings for the* 707

Many cities of the world have come closer together in the short year since the Boeing 707 was put in transatlantic service by Pan American World Airways, October 25, 1958.

Janitrol duct couplings have contributed to the history-making performance of this famous jet transport. The aircraft's wing anti-icing, air conditioning, and engine air extraction systems use an impressive number of Janitrol couplings.

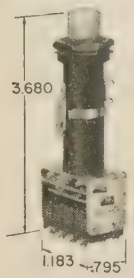
The unique capabilities in Janitrol's design and production of couplings, pneumatic controls, heat exchangers, and related components and subsystems are fully described in a new brochure entitled "Janitrol Resources." You are invited to write for a copy, on your letterhead, please. Janitrol Aircraft Division, Surface Combustion Corporation, 4200 Surface Road, Columbus 4, Ohio, BRoadway 6-3561.

JANITROL®

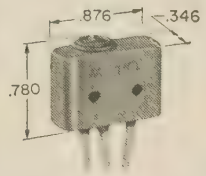
pneumatic controls • duct couplings and supports • heat exchangers • combustion equipment for aircraft, missiles, ground support

Write in No. 163 on Reader Service Card at start of Product Preview Section

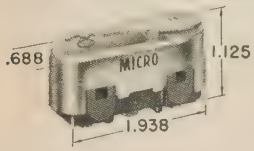
These 21 switches represent the widest for aircraft, missile, rocket, launcher,



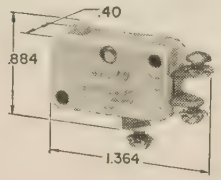
Series "54PB" alternate-action pushbutton—Lighted pushbutton saves panel-space, provides visual indication. Two-level position of button offers additional indication. Each operation transfers circuit of the maintained contacts.



Series "SE" small, sealed switch—Smallest environment-free switch. Potted leads. Leaf and roller-leaf auxiliary actuators available.



Series "HS" hermetically sealed switch—All seals in accordance with Par. 5.2.2, MIL-E-5272A. Insures constant operating characteristics in all atmospheric conditions.



Series "V3" high temperature basic switch—Synthetic mica case withstands radiation, 600°F temperatures. 30 vdc rating: ind. 10 a, res. 10 a, motor 6 a.

Each of the switches illustrated on these pages represents a different series of MICRO SWITCH precision Switches . . . Each switch has been designed to high reliability standards for a particular purpose . . . Each series includes many variations—sizes, weights, contact arrangements, electrical characteristics, housings, actuators, sealing, temperature, shock and mechanical characteristics . . . For example, there are 100 different switches in the "EN" Series . . . No other source of precision switches offers as broad a line . . . Furthermore, no other can offer the services of as large a staff of Application Engineers—in branch offices at strategic points throughout the country. Consult the yellow pages.

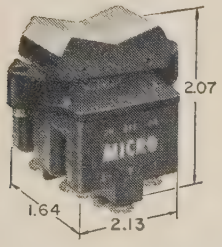
MICRO SWITCH . . . FREEPORT, ILLINOIS
A division of Honeywell
In Canada: Honeywell Controls Limited, Toronto 17, Ontario

Honeywell
MICRO SWITCH Precision Switches

Series "HR" hermetically sealed switch—For reliable use in —65°F to 600°F temperatures. Roller-plunger is adjustable. Designed and constructed for the roughest airborne use.

Series "ET" electrically released toggle switch—Works as a momentary action switch, but is converted to maintained contact when built-in solenoid is energized. Permits remote electrical release. Environment and immersion-proof enclosure. Available in 1 or 2-pole design.

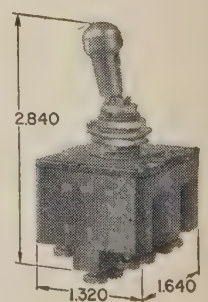
Series "EN" impact-resistant switch—Compact, environment-proof, corrosion-resistant switch. Has miniature plug-in receptacle. Two spdt switching units.



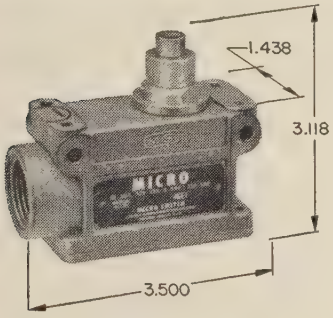
Series "TP" rocker-actuated key switch—Provides position and edge-light indication. Rugged, sealed case with stepped terminal design. Available with 1, 2 or 4-pole circuitry.

Series "TL" toggle switch—Rating at 28 vdc: res. 20 a, lamp 7 a, ind. 15 a. Available with variety of toggle lever positions. Provided in 1, 2, and 4-pole design.

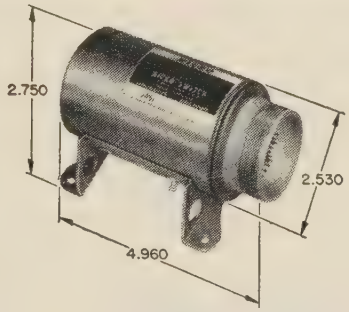
Series "TL" pull-to-unlock toggle—Rugged, sealed 4-pole toggle switch has integral pull-to-unlock lever. Available in a variety of locking arrangements. Also in 1 or 2-pole designs.



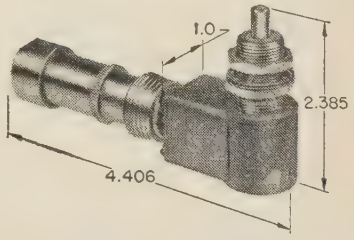
available range of precision switches marine and ordnance applications



Series "CE" G.S.E. limit switch—Weather-proof, corrosion-resistant indicator and limit switch. Rugged push plunger actuator.

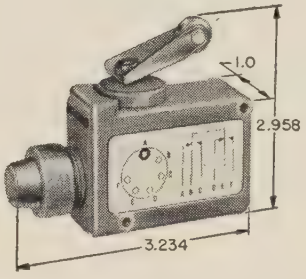


Series "1RS" high reliability telemetering switch—For missile program sequencing. 24 gold-contact switches and rotary solenoid in hermetically sealed container.



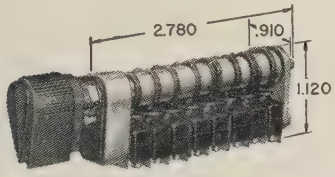
Series "EN" shock-resistant switch—Meets requirements of U.S.N. Bureau of Ordnance for shipboard launching equipment. Environment-proof construction.

Series "EN" linkage-actuator switch—Rotary actuator adjustable through 360°. 4-circuit basic switch. Rating 10 a, 115/230 vac, 30 vdc. Environment-proof housing. Potted, sealed leads.

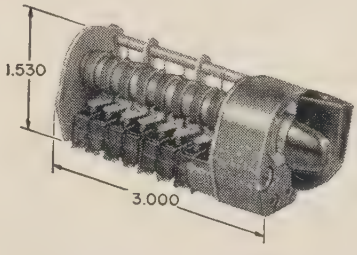


Series "EP" roller lever switch—Rugged, sealed two-hole side-mount enclosure. Two high-capacity spdt basic switches. Sealed connector receptacle.

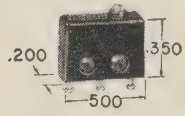
Plug-in Limit switch—Series "200LS"—Heavy duty switch for indicator and limit functions in G.S.E. applications. Switch can be replaced in seconds. Available in variety of actuator designs.



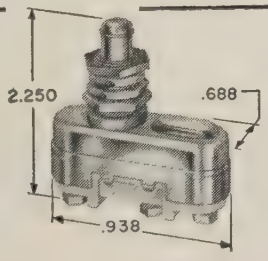
Series "17AS" rotary selector switch—Compact assembly handles eight separate circuits with infinite switching sequence. Available with fewer switch units.



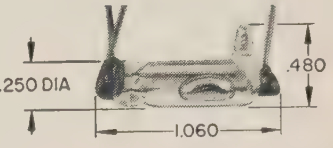
Series "28AS" cock-and-fire rotary—Positive, snap detent positions. Reliable operation, non-tease circuitry. Innumerable switching sequences. Available potted in steel housing.



Series "1SX" sub-miniature switch—Smallest precision, snap-action switch. Big switch features: two generous-sized mounting holes, rugged easy-to-wire terminals, 5-amp capacity at 115/230 vac.



Series "HT" 1000°F switch—World's "hottest" precision switch. Operates reliably near afterburners, etc. Bushing mount. Also available with roller plunger and side mount, pin plunger.



Gyro mercury switch—Most sensitive tilt switch (0.15°). Low angle and low mass shift make it ideal control for vertical gyros, stable platforms, rockets. Reliable operation at—65°F.

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Ultrasonic Flaw Detection now Ultra-Practical in every shop!

THE NEW BRANSON

SONORAY®

MODEL 5

pulse-echo type instrument

combines the highest performance yet achieved with the smallest size, weight and price in the field. It is equally at home in contact and immersed work.

Every metalworking shop can now afford quick, accurate, inexpensive tests on internal structure of Bar Stock, Strip, Plate, Castings, Weldments. Brazed Assemblies, Machinery Shafts, etc.

SONORAY® Ultrasonic Flaw Detector testing aluminum bar stock; easily probes the full 12-foot length as well as through thickness.

SONORAY® Model 5 clearly resolves 3/64" FBH at 3/16" in contact at 2.25 mc/s — reveals 1/64" FBH full-scale at 2.25 and 5.0 mc/s — brings laboratory precision into the field with simplified controls, a weight of only 37 pounds and a price of . . . . . $2750.

Use coupon for Bulletin T-200

BRANSON INSTRUMENTS, Inc.
11 Brown House Road • Stamford, Conn.

BRANSON INSTRUMENTS, INC.
11 Brown House Road, Stamford, Conn.
Send SONORAY® Bulletin T-200 to

NAME_____

FIRM_____ DEPT._____

ADDRESS_____

Write in No. 165 on Reader Service Card

LEADER for classified films

The problem of obtaining acceptable classified film leader of a uniform nature has been resolved for defense contractors and others concerned with classified motion picture film with the availability of production leader, says **Consolidated Film Industries, Dept. S/A, 959 Seward St., Hollywood 38, Calif.** The leader contains the appropriate classification and extracts of the Espionage Act or the Atomic Energy Act of 1954.

Normal or reverse printing is available. The leader comes in 1000-ft lengths and in 16 or 35mm sizes.

Write in No. 304 on Reader Service Card

TRANSIT CASE for components

This transit case is patterned for critical and delicate missile and electronic components. It offers maximum protection in a minimum amount of space, according to **Standard Plastics, Inc., Dept. S/A, Fogelsville, Pa.** It has precisely molded snug liners to fit any number of irregular shaped components for transit carrying cases, handling trays tote boxes and shipping cases.

Characteristics allow a full range of resilience with a neutral Ph factor and offer resistance to time, temperature, chemical action, fungus and vermin.

Write in No. 305 on Reader Service Card

POWER SUPPLY is transistorized

Five regulated outputs, which are protected from overload and short circuit, are featured in the Model PS-25 transistorized power supply for airborne use, says **Southwestern Industrial Electronics Co., Dept. S/A, 10201 Westheimer Rd., Houston, Texas.** Outputs are 17½ V dc, positive and negative; 110 V dc, positive and negative; and 6.3 V ac.

Regulation is one per cent for the 110-V outputs and five per cent for the others. Power required is 115 V ac, plus or minus ten per cent, 350-450 cps single phase at four amps, and 28 V dc at 100 ma.

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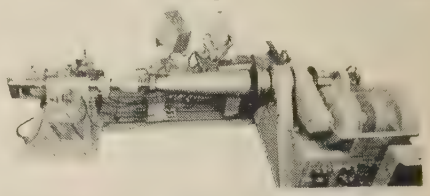
more on page 242

Announcing
COMPLETELY FLEXIBLE
PHOENIX
Powerspinning

To meet the challenge of the space age



Vanguard, Polaris, Talos, Jupiter and latest space projects utilize vital PHOENIX POWERSPUN components and assemblies.

Nose and tail cones, nozzles, venturi, bulkheads, guide vanes, exhaust hoods etc. are economically produced on Phoenix automatic, mechanical and manual metal spinning equipment in conjunction with complete welding, polishing, deep drawing and allied facilities.

High voltage spark-gap assembly produced by PHOENIX spin-fab method.

A Phoenix FIRST!
Flexible POWERSPINNING of metals, gauges and diameters heretofore thought impossible to form by spinning.

PHOENIX Powerspinning

The modern way to

HYDRAULIC-SPIN
FLOW-SPIN
TURN-SPIN
SHEAR-SPIN
MECHANI-SPIN
AUTO-SPIN

Write for 40 Page Brochure

PHOENIX PRODUCTS CO. 4741 North 27th St. Milwaukee 9, Wis.

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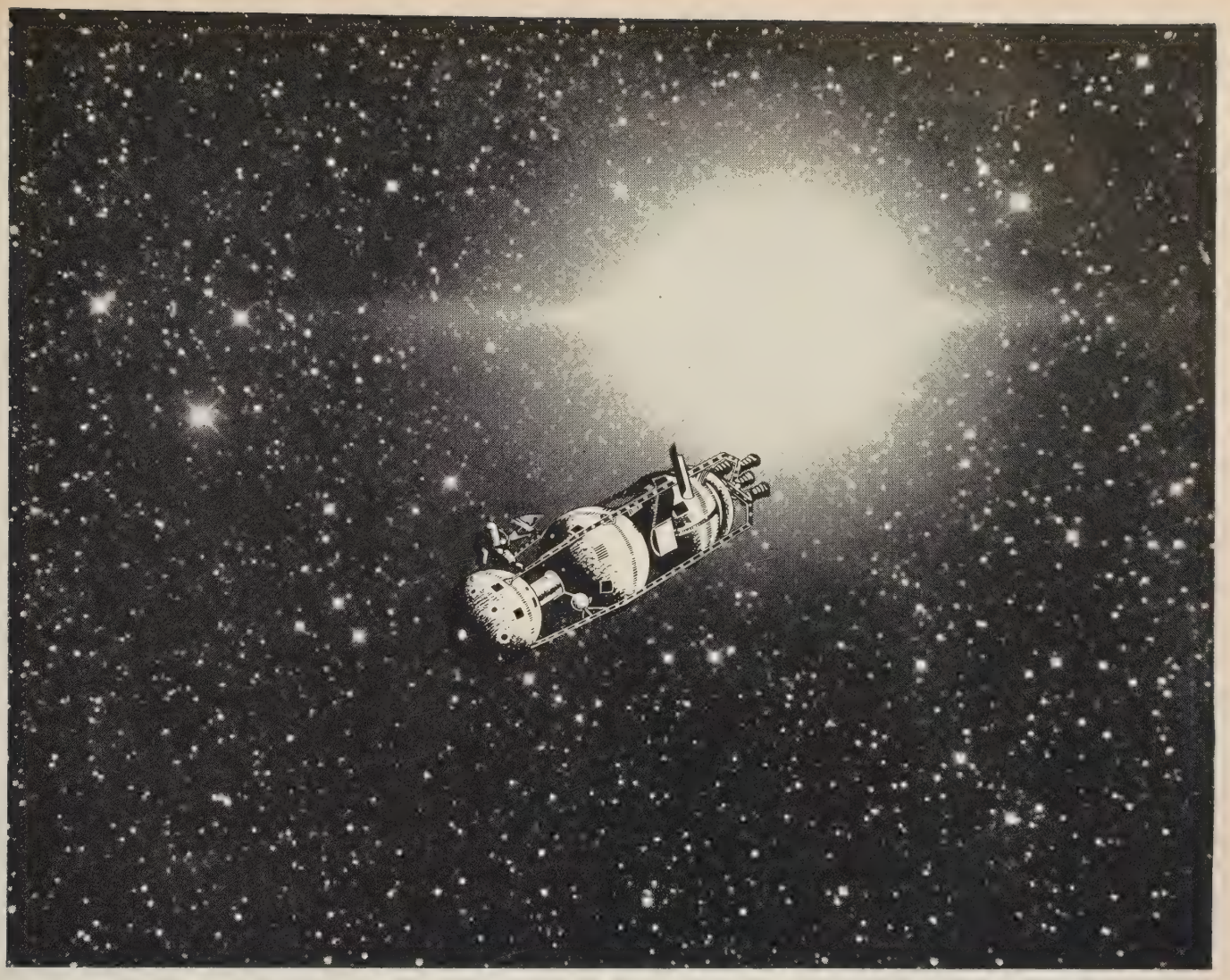

This low-cost computer eliminates the "middleman" between the engineer's problem and answer!

Royal Precision

LGP-30

Engineers in the aircraft and missile field get answers *fast* when they have direct access to the powerful LGP-30 electronic computer marketed by Royal McBee. Many are now solving such problems as wind tunnel and flight test data reduction, guidance system design, transducer calibrations, flutter and vibration studies, component reliability evaluations, specific impulse calculations and thermal stress distribution—*at desk-side!* Reason: this computer is programmed and operated by the engineer himself to cut through the maze of mathematical calculations demanded by today's complex aircraft design requirements.

The LGP-30 is low in cost – about the price of a good engineer – and is simple to program and operate. Its 4096-word memory is comparable to computers many times its size and cost. User-engineers develop a man-machine relationship to the point where it becomes an extension of their own thinking capacity. Bolder, more creative engineering almost always results.

No site preparation is necessary. Plug the LGP-30 into the nearest standard outlet and it is ready to go to work. Customers have access to an extensive library of programs and sub-routines—as well as an active users organization.

Royal Precision Corporation

Royal Precision is jointly owned by the Royal McBee and General Precision Equipment Corporations. LGP-30 sales and service are available coast-to-coast, in Canada and abroad through Royal McBee Data Processing offices. For information on the LGP-30 write **ROYAL McBEE CORPORATION**, data processing division, Port Chester, New York

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ETALON 23C MICROMETER

one piece stainless steel spindle

HARDENED AND GROUND FROM THE SOLID

• Reads to .0001" • Heavy duty tungsten carbide measuring faces • Forged frame • Dull chrome finish on thimble and barrel • Quick acting positive lock • Built for accuracy under the most rugged applications • Furnished in handsome contour case

AVAILABLE INDIVIDUALLY OR IN SETS FROM 0 to 12"
WRITE FOR CATALOG on complete line of precision measure instruments

ALINA CORPORATION

122 East Second St., Mineola, L.I., N.Y.

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For Safe Flexible Fluid Handling Lines—
specify **CHIKSAN SWIVEL JOINTS**

FOR MISSILE FUELING

Swivel Joints and assemblies to handle cryogenic liquids and fuels in ground loading and topping hose. Assemblies developed to handle services ranging from −320°F to +600°F and pressures from 20" vacuum to 15,000 psi.

FOR GROUND SUPPORT EQUIPMENT

Loading arms and flexible transfer assemblies for handling Lox, N_2, He, JP Fuels, H_2O_2 and Hot Gases. Sizes range from ¼" to 16". Corrosion resistant steel, nickel, brass, aluminum, bronze and other metals available.

FOR GROUND HANDLING EQUIPMENT

Swivel Joints and assemblies to handle hydraulic, pneumatic, and fuel systems on launching vehicles and missile transporters. Units for rotation in 1, 2 or 3 planes in widest variety of metals, pressure and temperature available.

FOR AIRCRAFT SYSTEMS

Compact, lightweight package units in ¼", ⅜", ½" and ⅝" O.D. tubing sizes. Pressures of 28" vacuum to 4,000 psig. Temperatures of −65°F to +275°F. AN and MS standard end connections.

CHIKSAN COMPANY
A SUBSIDIARY OF FOOD MACHINERY AND CHEMICAL CORPORATION
CHIKSAN COMPANY - BREA, CALIFORNIA

Send for informative Bulletin 558

59-41

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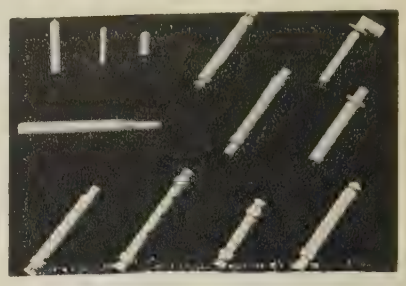
LOW-PASS RF FILTERS are miniaturized



This line of low-pass rf filters have cutoff frequencies from 0 to 1250 mcps and at frequencies 1.2 times cutoff, the attenuation is 20 db or higher. At 15 times cutoff, it is at least 60 db, says **Telonic Industries, Inc., Dept. S/A, Beech Grove, Ind.**

The overall length of filters down to 100 mcps cutoff is only 3½ in. The units are finished in nickel-plated brass, with BNC male and female end connectors. Input power is normally 10 watts, maximum; impedance 50 ohms.

Write in No. 307 on Reader Service Card

CERMET is spray-welded

A spray-welded cermet powder that fuses with the parent metal can be used to rebuild valves, spindles, pump sleeves and other equipment, according to **Republic Hardfacing Corp., Dept. S/A, 479 Broadway, Bedford, O.** Hardfacing with the material stops the burning effects of exhaust gases, erosion, necking, and corrosion on engine valves.

The cermet will not crack or spall under severe shock, heat, wear, or abrasion. Its properties make it suitable for extensive use in the jet engine field.

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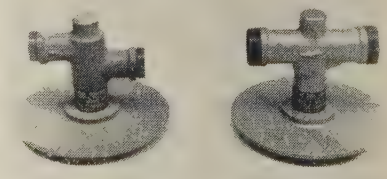
FUEL VALVE is flush-mounted



This aircraft aluminum fuel control valve is a flush-mounted unit, says **Hydrodyne Corp., Dept. S/A, 7352 Coldwater Canyon Ave., North Hollywood, Calif.** It is designed to handle JP4 fuel and is manually operated.

The device is available in normally-open or normally-closed designs.

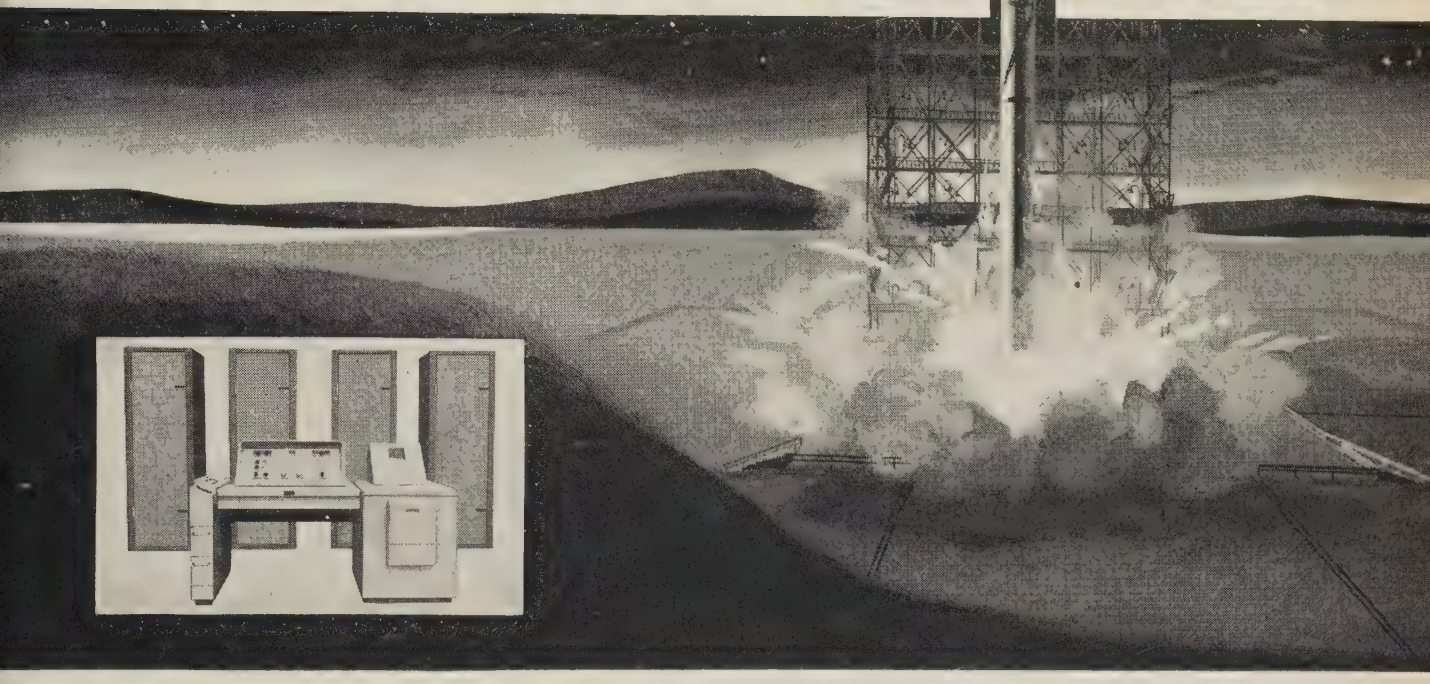
Write in No. 309 on Reader Service Card

more on page 246

The Checkout that says "GO" or "NO GO"

APCHE

(Pronoun
"AP-SHE"



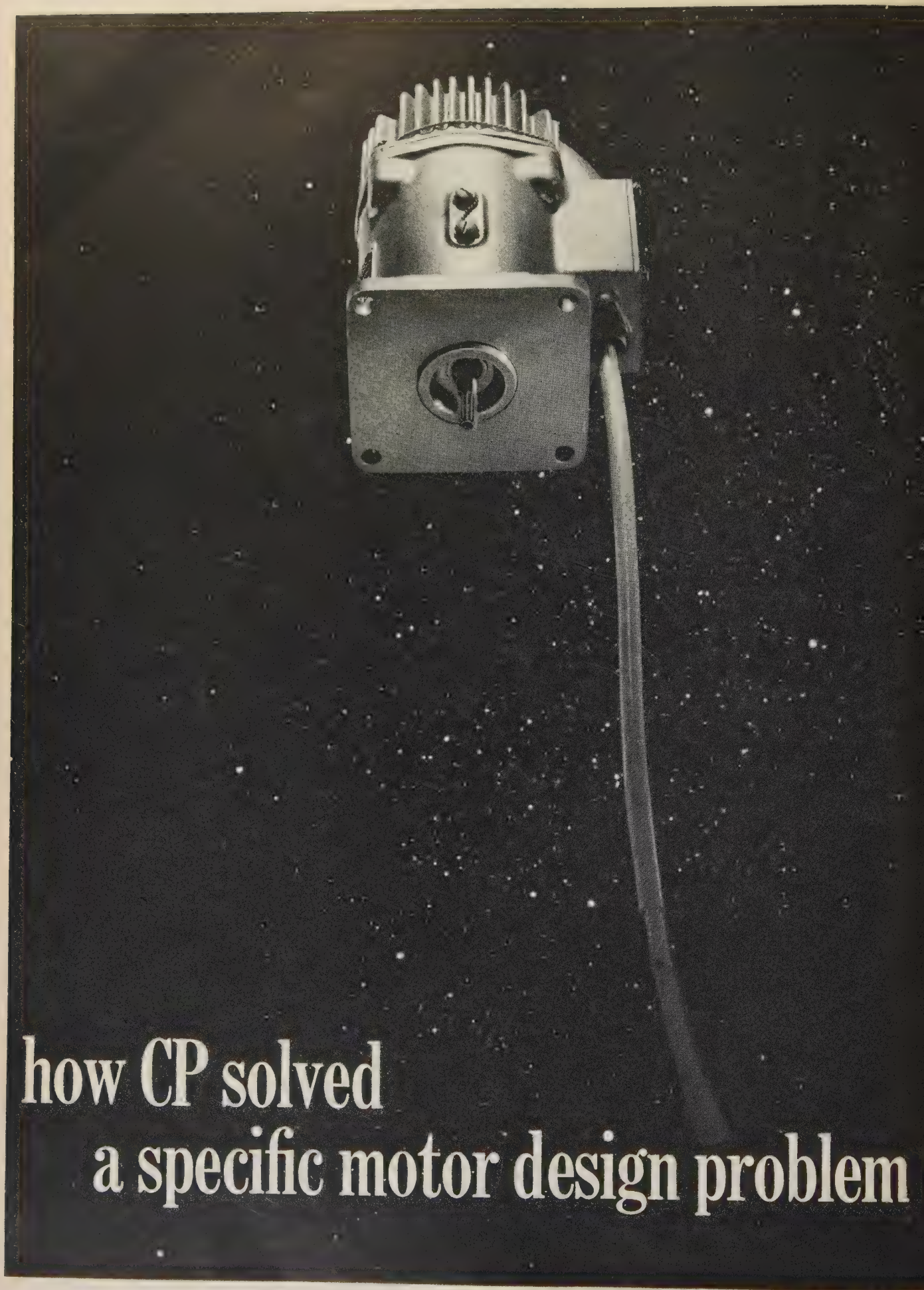
APCHE (Automatic Programmed Checkout Equipment) is a solid-state, universal, high-speed, highly reliable, compact general-purpose tester designed especially for automatic checkout of aircraft, missile and space systems and their supporting systems. In its various versions (differing in input media, size and weight) APCHE installations may be fixed, mobile, airborne or submarineborne. APCHE was designed and is being produced as a part of RCA's ground support electronics subcontract from the Convair (Astronautics) Division of General Dynamics Corporation, prime contractor for the ATLAS Intercontinental Ballistic Missile.

The system being supplied to Convair for the ATLAS Program includes a console and four rack cabinets providing both analog and discrete test functions with a resulting printed and GO-NO GO indication. As a product of RCA's Missile Electronics and Controls Department, Burlington, Massachusetts, APCHE is one of the latest RCA developments in the field of military weapon readiness equipments.

RCA Tmk(s) ®

RADIO CORPORATION of AMERICA

DEFENSE ELECTRONIC PRODUCTS • CAMDEN, NEW JERSEY


how CP solved
a specific motor design problem

PROBLEM
of Aircraft Component Supplier

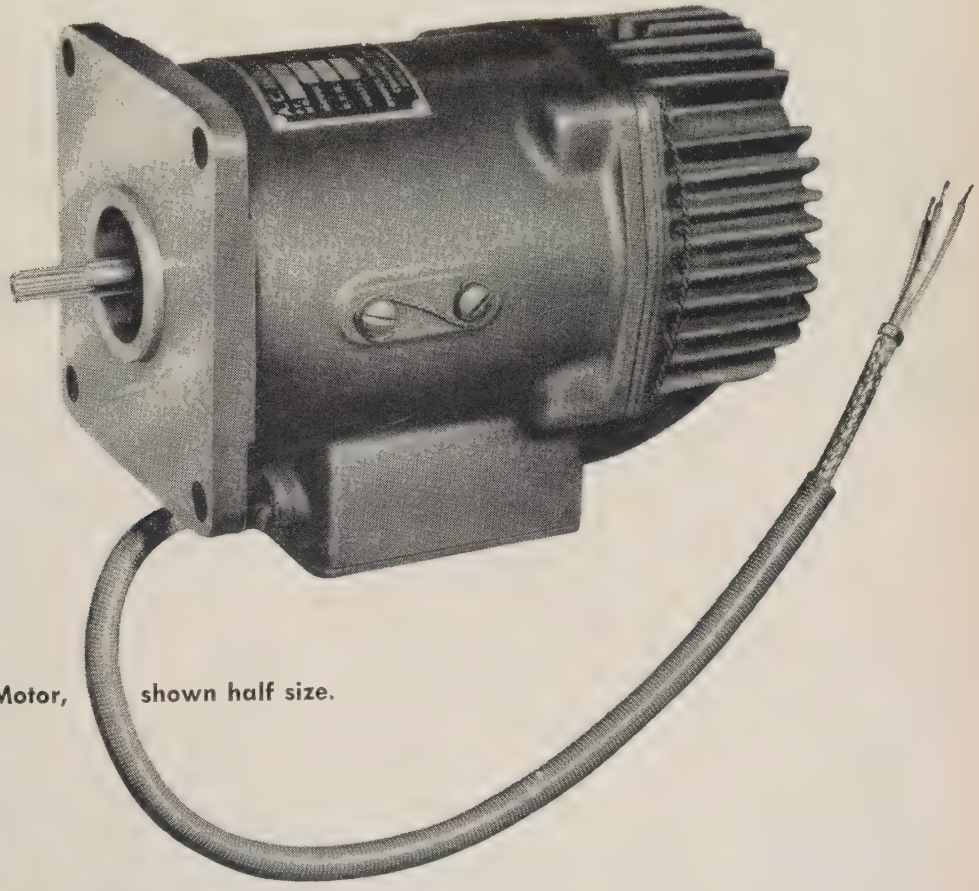
Obtain a motor that would . . .

1. Drive a linear type actuator for automatic pilot controlled elevator tab system.
2. Withstand duty cycle of ½ second "ON", and 2½ seconds "OFF."
3. Have ac solenoid brake incorporating holding torque of 4.5 to 8.5 pound-inches. This brake to stop the rotor —which is turning at 11,000 rpm—every 3 seconds without overheating.
4. Prevent overriding of tab system by stopping rotor within 40 revolutions at no load.

SOLUTION
by Chicago Pneumatic

All specifications were met by a CP-841J7 Actuator Motor, using the patented CP Low Inertia Rotor. It successfully met the "ON-OFF" duty-cycle requirements with the essential fast braking action needed to prevent overriding.

CP has immediately available hundreds of basic designs and types of aircraft motors and actuators suitable for adaptation to your immediate requirements. In addition, a competent staff of motor specialists will work with you to help solve your motor problem. For full information write *Chicago Pneumatic Tool Company, 8 East 44th Street, New York 17, N. Y.*



CP-841J7 Actuator Motor, shown half size.

Chicago Pneumatic

AVIATION ACCESSORIES • PNEUMATIC TOOLS • ELECTRIC TOOLS • DIESEL ENGINES • ROCK DRILLS • HYDRAULIC TOOLS • VACUUM PUMPS

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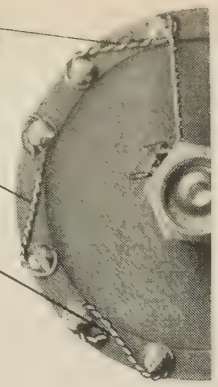
eliminate safety wire

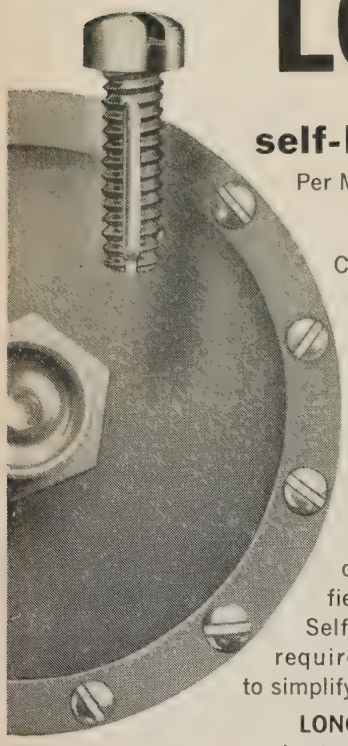


on airborne accessories with...

LONG-LOK

self-locking screws

Per MIL-F-18240



Critical **weights** and needless and costly man-hours of **assembly time** are being saved through the use of **LONG-LOK** Self-Locking Screws on pressure switches, motors, pumps, valves and other airborne accessories.

Many companies in the aircraft, missile and rocket fields are using **LONG-LOK** Self-Locking Screws per the requirements of MIL-F-18240 to simplify their assemblies.

LONG-LOK Self-Locking Screws are heat, vibration, shock and impact resistant. They are reuseable and can be head marked for self-lock identification per specification. Increased reliability of component **and** system is assured.

LONG-LOK Self-Locking Screws are solving new fastener problems every day. They could be the answer to your needs.

Write for Catalog LL-59.

LONG-LOK CORPORATION

2601 COLORADO AVENUE • SANTA MONICA, CALIFORNIA

Write in No. 171 on Reader Service Card

SILVER-ZINC CELL puts out 80 watt-hours

This 4-lb, 5 oz. silver-zinc cell can provide outputs of 80 watt-hours per pound and is said to combine the advantages of the primary and the rechargeable types of battery systems. The model PM 200 is said to have an operation temperature range of +165° F to 0° F, down to below −65° F with heaters, according to **Yardney Electric Corp., Dept. S/A, 40-50 Leonard St., New York, N. Y.** Charge retent of up to 95% after one month's activated stand is claimed.

At a fixed load, and with temperature limits within ±10 F, plateau voltage regulation is within ±2%.

Write in No. 310 on Reader Service Card

SERVO MOTOR meets BuOrd specs

This ¾ in servo motor conforms to BuOrd standards and is designed and guaranteed to operate at ambients to 200 deg C. It is completely enclosed on the back end and can be certified environmentally under Mil E-5272A and Mil 6-5422C, says **Servo Dynamics Corp., Dept. S/A, Somersworth, N. H.** Part No. 8M100, produces 1 in oz of torque at zero rpm.

It may be fitted with a variety of output shaft configurations or gear reductions to customer specifications. Input power range is 6 to 115 v ac.

Write in No. 311 on Reader Service Card

MAGNETIC TRIGGER ignores line transients

A series of half-wave magnetic triggers for use with the C35 or equivalent series of silicon controlled rectifiers has been designed with the transfer characteristic largely independent of voltage and frequency of the primary power supply, says **ACF Industries, Inc., Dept. S/A, 11 Park Pl., Paramus, N.J.** The Model 408's output presents a steep wave front to the rectifier, allowing precise determination of firing angle.

Operating range is from 50 through 400 cps. The trigger is insensitive to line transients such as switch surges, commutator noise, and capacitance to ground.

Write in No. 312 on Reader Service Card

SILICON RECTIFIER is very reliable

Voltage ratings to 600 PIV are offered in a new silicon power rectifier that is designed for high reliability, says **Semiconductor Corp. of America, Dept. S/A, 16629 Gramercy Pl., Gardenia, Calif.** Units are available with current ratings to 18 amps dc at 100 deg C ambient and forward drop of less than 0.8 V.

The hermetically sealed unit has a silver anode lead and solid copper base. Prior to shipment, each unit is cycled between −65 & 200 deg C for six hrs, and is leak and load-tested.

Write in No. 313 on Reader Service Card

CARCINOTRONS have special tuning

Eight electrically compatible carcinotrons make up this new series, the first such to use wideband sole tuning without frequency or power holes when a tube is operated into as much as a 2:1 mismatch, according to **Litton Industries, Dept. S/A, 960 Industrial Rd., San Carlos, Calif.** Wider-than-normal-band RF output couplers enable the carcinotrons to minimize components such as antennas, waveguide plumbing, and load isolators.

Tuning rates are said to be the fastest available, and size and weight the smallest to date.

Write in No. 314 on Reader Service Card

more on page 248

Model 5601

DATA LINK RECEIVER

LEAR ASTRONICS BUILDS *PROVEN* OPERATIONAL MISSILE COMMAND GUIDANCE RECEIVERS

Typical of Lear avionic capabilities is the Model 5601 Data Link Receiver aboard the Boeing Bomarc missile. Qualified to operate in severe missile environments, it adapts to a wide variety of command and data link applications, tunes to over 1,000 separate RF channels.

Write for technical information to:

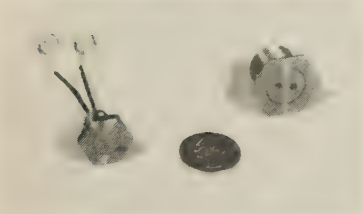
LEAR ASTRONICS DIVISION

3171 SOUTH BUNDY DRIVE • SANTA MONICA, CALIF.

GUIDANCE AND CONTROL SYSTEMS • AUTOMATIC FLIGHT CONTROL • DATA LINK AND TELEMETRY • NAVIGATION

Write in No. 161 on Reader Service Card at start of Product Preview Section

RELIEF VALVES for space vehicles



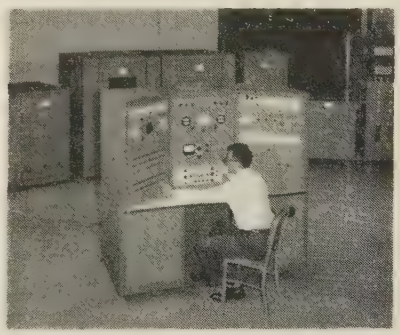
A pressure-release blowout valve for space vehicle mechanisms that operates on a pressure differential as low as five psi is one such device offered by **ACF Industries, Inc., 11 Park Pl., Paramus, N.J.** The valve exhausts a high pressure medium to a lower pressure medium.

The 16-g valve is reliable to within plus or minus two psi, can withstand a shock of 20 g's at 11 msec in all planes, and has a temperature range from —50 to ±165 deg F. Another blowout valve in the line is an electrically operated, one shot squib-type that evacuates a high pressure chamber to atmosphere by first opening one chamber to another. The unit has an equivalent .015-in. hole for evacuation. It operates on an impulse of three V, 2500 ergs, or 100 V, 100 ergs. Shock is 1000 g's in all planes. Weight is 19 g.

Write in No. 315 on Reader Service Card

RF POWER SYSTEM delivers 3 megawatts

Model 221 M system includes an rf magnetron driver unit and power supply, a modulator and power supply, a trigger generator, a field exciter, a tank assembly for a high-power pulsed microwave tube, and a complete oil and water cooling system for generating and handling rf

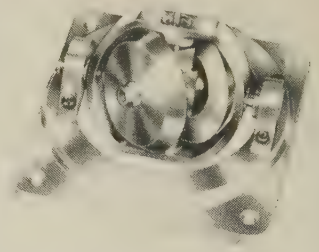


power, says **Levinthal Electronic Products, Inc., Dept. S/A, Stanford Industrial Park, Palo Alto, Calif.**

Using the Litton L3035 klystron, it delivers 3 megawatts in the L band. With the L3250, it delivers 10 megawatts. Driving the Varian VA87, the unit gives 1.3 megawatts in the S-band. The system is also compatable with the classified Sperry SAC 42 klystron.

Write in No. 316 on Reader Service Card

SPLIT ROTOR GYRO is low in cost



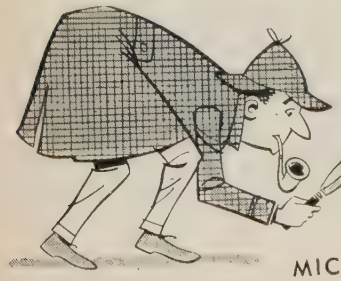
This split rotor, solid bar inner gimbal gyro for small, short-range missiles and drones can be mass produced at about ¼ the cost of a conventional type, says **Clary Dynamics, Dept. S/A, 408 Junipero St., San Gabriel, Calif.** The spring-wound, two-axis instrument attains drift accuracies of 0.1 deg/sec and resists shocks to 100 g's, acceleration to 30 g's, and vibration to ten g's.

Speed and uncage time is 0.1 sec maximum, and optimum performance running time is four min with an eight-min rundown time. Resistive, commutator or selsyn pickoffs are available in the gyro, which may be kept in wound condition indefinitely and reused repeatedly without loss of accuracy.

Write in No. 317 on Reader Service Card

more on page 252

FOR LEAK-DETECTION DEVICES



OHIO

NITROUS OXIDE

READILY DETECTS MICROSCOPIC LEAKS

Infrared determination of nitrous oxide provides a safe, sensitive and flexible method of leak detection. This method is not affected by usual atmosphere components such as moisture, carbon dioxide and hydrocarbons. In addition, nitrous oxide will not harm pieces being tested and is more economical than other gaseous agents.

OHIO NITROUS OXIDE: ODORLESS AND INERT • NONTOXIC • NONCORROSIVE • NONFLAMMABLE • ECONOMICAL

FREE TECHNICAL AID is available in the use of nitrous oxide for leak detection. For further information, please request the following bulletins:

1A Chemical, Physical and Pharmacological Properties of Nitrous Oxide with Results of Corrosion Tests

1B Gas Service Equipment for Nitrous Oxide Supply

OHIO *Ohio Chemical*

OHIO CHEMICAL & SURGICAL EQUIPMENT CO.

(A Division of Air Reduction Company, Incorporated) AIRCO

MADISON 10, WISCONSIN

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Can Tiny Bearings "Take It"?

MPB pivot bearings can. Smaller than ½" O.D., a single bearing can withstand severe shock, thrust *and radial* loads, and constant vibration — performs faultlessly with low frictional torque.

Write MPB, Inc., 1412 Precision Park, Keene, N. H.

MPB helps you perform miracles in miniaturization

MPB

MINIATURE PRECISION BEARINGS INC.

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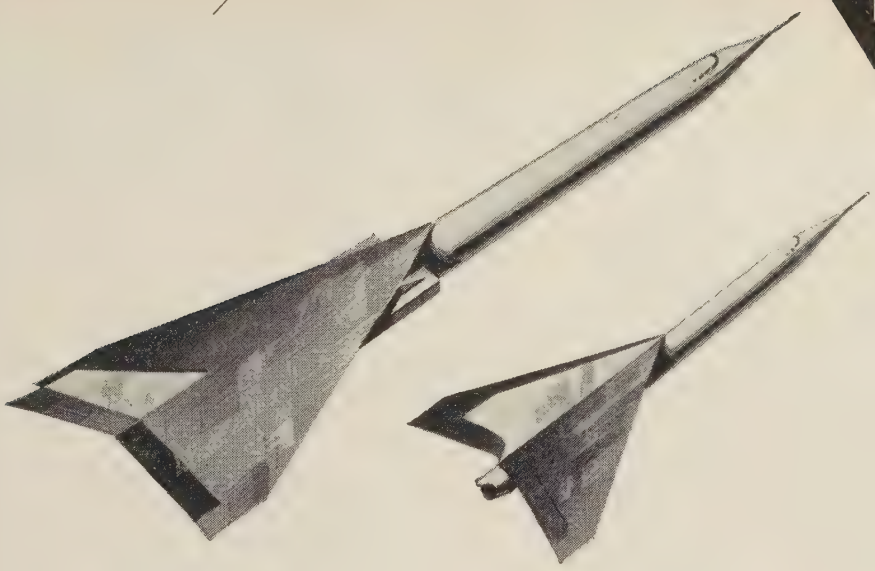
ARMCO STEELS / for Aircraft and Missiles

New steels are born at Armco



ARMCO PRECIPITATION-HARDENING STAINLESS STEELS . . .

Used in Today's Aircraft-- Planned for Tomorrow's

Armco's high strength-weight ratio stainless steels, PH 15-7 Mo, 17-7 PH and 17-4 PH, are widely used in our newest missiles, fighters, and bombers, and in *all* the new jet-powered commercial airliners.

They are specified for airframe structures and skins, pod assemblies, engine parts, accessories and instruments because they have a unique combination of properties—light-weight strength at temperatures to 900-1000 F, good corrosion resistance, and excellent fabricating characteristics that assure economical producibility.

These properties have given designers new opportunities to create reliable components that withstand the heat and stresses of jet-propelled flight . . . and save weight.

Tomorrow's aircraft now on drawing boards, will utilize the many advantages offered by these special Armco Stainless Steels to solve some of the complex problems imposed by speeds of Mach 2 and beyond.

Consider the design and production possibilities of Armco Precipitation-Hardening Stainless Steels for the units *you* are making or designing. Mail the coupon for complete information on their properties and fabrication.

ARMCO STEEL CORPORATION
3439 Curtis Street, Middletown, Ohio
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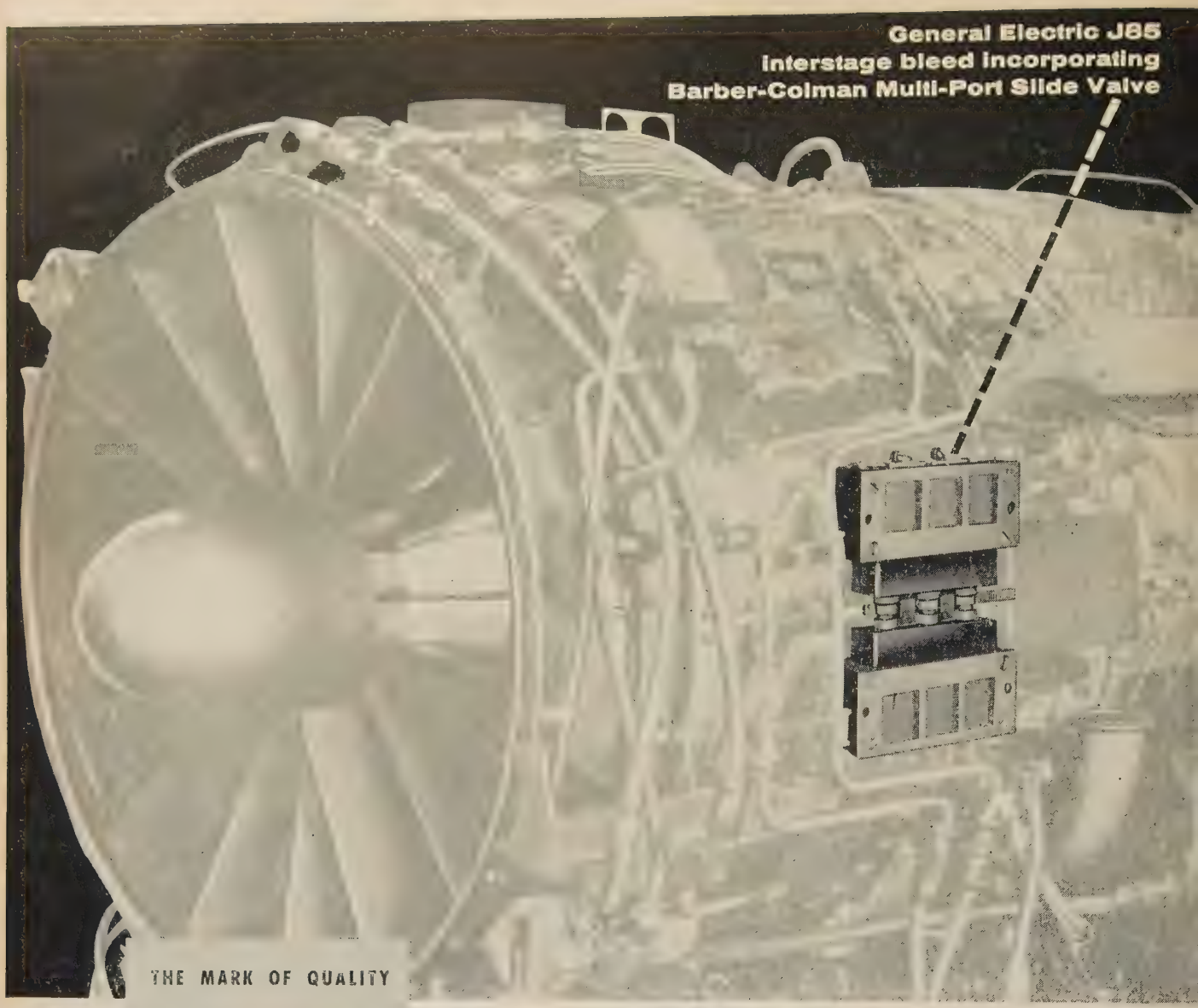
CITY_____ ZONE____

STATE_____

ARMCO STEEL

Armco Division • Sheffield Division • The National Supply Company • Armco Drainage & Metal Products, Inc. • The Armco International Corporation • Union Wire Rope Corporation

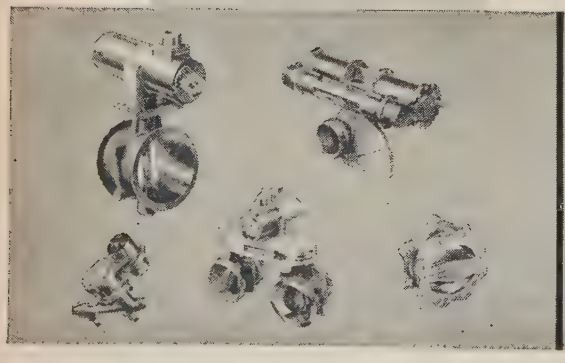
Write in No. 175 on Reader Service Card at start of Product Preview Section

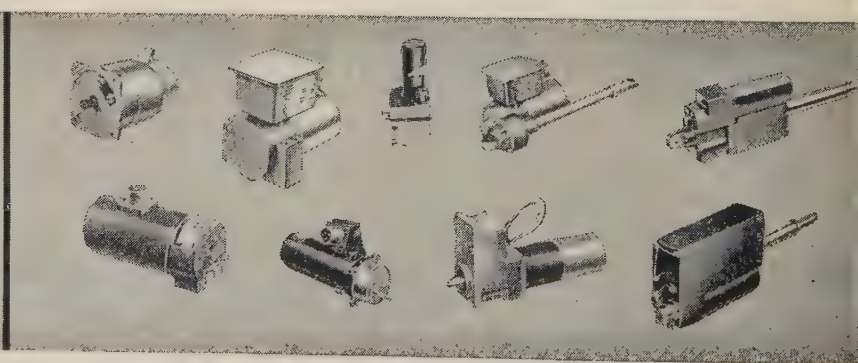


THE MARK OF QUALITY

BARBER COLMAN

Aircraft and





AIR VALVES — A wide variety of electrically and pneumatically operated air valves for temperature and pressure-control applications. Butterfly, check, poppet, slide, and automatic drain types.

ACTUATORS — Rotary and linear types featuring a wide range of gear reductions, switching and mounting details. Available either as standard units or special designs to fit various applications. Designed to applicable military specifications.

New Barber-Colman Multi-Port Slide Valves developed for General Electric to help give the J85 high performance and efficiency over a wide operating range

In addition to its compact size and light weight, General Electric's new J85 turbojet features high performance and high efficiency over a wide range of operating speeds. Barber-Colman, working with General Electric engineers, developed a unique multi-port slide valve to meet special performance and package requirements. This valve, shown at the left, plays a vital part in the high efficiency of this engine.

Manufactured exclusively by Barber-Colman Company, these valves are made in four-port and six-port types for use in J85 turbojets which will power many of the nation's most advanced piloted aircraft, missiles, and drones. J85 applications include the Northrop T-38 "Talon," and N-156F "Freedom Fighter," the McDonnell GAM-72 decoy missile, and the Radioplane Q-4B target drone.

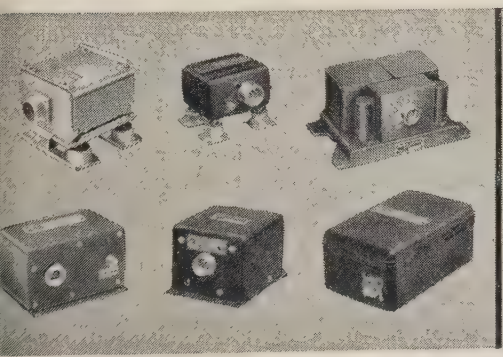
Characteristics of Barber-Colman multi-port slide valves are as follows: Maximum temperature — 630°F. Maximum pressure — 60 psig at 630°F. Ambient temperature — 65°F to 350°F. Total leakage — 1.55 lb/min at 60 psig and 630°F.

This valve story illustrates the typical way Barber-Colman works with leaders of the aircraft and missile industry to apply our specialized know-how to major industry projects. Consult the engineering sales office nearest you: Baltimore, Boston, Fort Worth, Los Angeles, Montreal, New York, Rockford, Seattle.

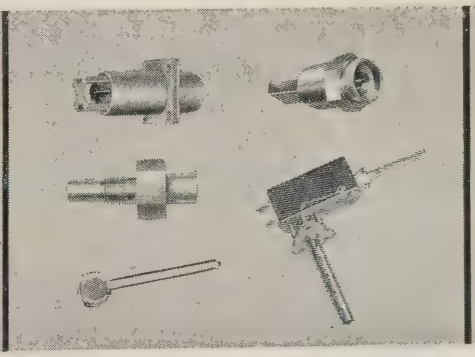
BARBER-COLMAN COMPANY

Dept. X, 1423 Rock St., Rockford, Illinois

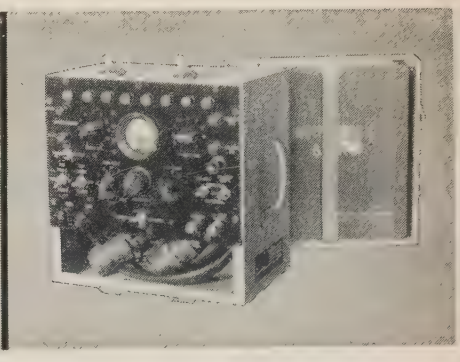
Missile Accessories



TEMPERATURE CONTROL AND POSITIONING SYSTEMS — Electronic, magnetic amplifier, transistor, or relay-controlled systems designed to meet your requirements.



TRANSDUCERS AND THERMOSTATS — Units for sensing compartment, duct, windshield temperatures. CEDAC system senses, controls temperature and/or airflow in ducts.



TEST EQUIPMENT — Compact electrical test units for quickly checking all components of a Barber-Colman control system installed in an aircraft. Special units for checking many electrical systems.

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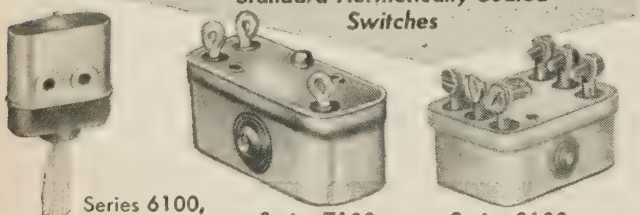
HAYDON . . . RELIABLE SOURCE FOR MINIATURE SNAP-ACTION SWITCHES

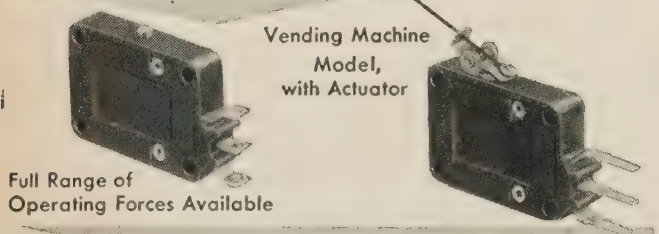
Standard Hermetically Sealed Switches



Series 6100, SPST | Series 7100, SPST | Series 8100, DPDT

These switches meet requirements of MIL-S-6743 and MIL-E- 5272A, Procedure II (vibration).

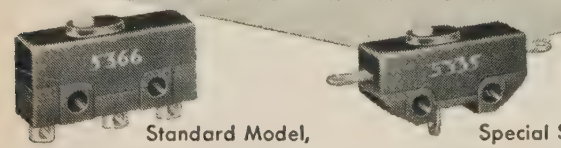
Series 5200 Plastic Cased Switches



Vending Machine Model, with Actuator

Full Range of Operating Forces Available

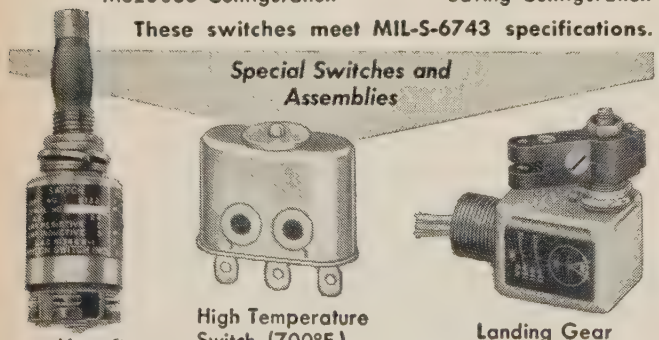
Series 5300 Plastic Cased Switches



Standard Model, MS25085 Configuration | Special Space-Saving Configuration

These switches meet MIL-S-6743 specifications.

Special Switches and Assemblies

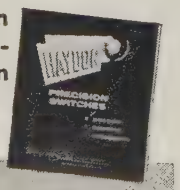


Aircraft Limit Switch | High Temperature Switch (700°F.) | Landing Gear Switch

These are only a few of the many precision switches developed by Haydon for aircraft and industrial applications. Haydon engineers are prepared to solve *your* switch design problems—or call on one of their twenty-three field offices for immediate help.

For accurate, dependable performance in miniature and subminiature switches, it pays to contact Haydon Switch!

As a starter, send for the new Haydon Catalog containing full data and specifications on standard and special precision switches.



HAYDON Switch INCORPORATED
WATERBURY 20, CONNECTICUT

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BEAM WELDER is versatile

The Model 2770 electron beam welder, which joins reactive and refractory metals, is a highly flexible laboratory and light production unit that welds by directing a beam of high-energy electrons on the work, says **NRC Equipment Corp., Dept. S/A, 160 Charlemont St., Newton 61, Mass.** The design insures a steady, continuous welding cycle regardless of operating conditions, and provides protection from gaseous discharges in the weld area.

Beam current of the welder is zero to 100 ma at zero to ten kv, or zero to 20 kv, depending on gun rating, and the power supply has a rating of 20,000 V maximum. Very fast welding, better bead, smaller heat-affected zone, and excellent penetration are among the characteristics of the beam welder.

Write in No. 318 on Reader Service Card

NUMERICAL CONTROL for machine tools

Two highly accurate and versatile numerical control systems for almost any type machine tool, new or retrofit, are offered by **United Aircraft Corp., Norden Div., Dept. S/A, Stamford, Conn.** The first offered is the Decasyn system which can be utilized to provide manual, semi-automatic and fully automatic machine tool operations.

Chief features include automatic zero offset and ability to display position.

Write in No. 319 on Reader Service Card

BUSHINGS are adjustable

A simple mechanical adjustment permits the radial dimensions of these unique bushings to be easily and exactly varied, says **Globe Bushing Corp., Dept. S/A, 12036 Vose St., North Hollywood, Calif.** The bushing design results in a convenient and low-cost method of maintaining an exact fit without expensive machining for applications such as close tolerance fasteners, salvage of oversize holes, and replacing of taper pins.

The adjustable wall-thickness bushing consists of a series of alternate male and female segments aligned axially. An axial compressive force applied to the bushing's ends causes the male segments to assume a smaller diameter, thus reducing the id of the bushing; the female segments simultaneously assume a larger diameter to increase the od. All segments are slit axially through one wall to provide ease of adjustment. The bushing is available in a large variety of materials, including Nylon, Teflon, and metals.

Write in No. 320 on Reader Service Card

AIRCRAFT PUMP assures pure air

The Model 373 aircraft pressurization pump assures delivery of pure air by virtue of its diaphragm-type construction, says **The Cornelius Co., Dept. S/A, 550 39th Ave. N. E., Minneapolis 21, Minn.** Being piston less, it requires no pump lubrication or carbon rings.

Other design advantages include elimination of unwanted friction, reduction of generated heat, and no loss in capacity during rated life. The Model 373 will operate for 1000 hrs of continuous or intermittent operation, and its rating is from zero to 25 psi at one cu ft per min of standard air at sea level. Weight, with an explosion-proof, 200-V ac motor, is four lbs or 4½ lbs with a ⅛-hp dc motor, also explosion-proof. Applications include pressurization of radar equipment, fluid systems, and water systems. The pump can also serve in de-icer systems or in ground support for preflight checkouts. Standard and high-altitude versions of the pump are available.

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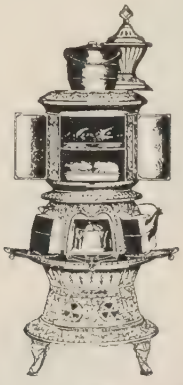
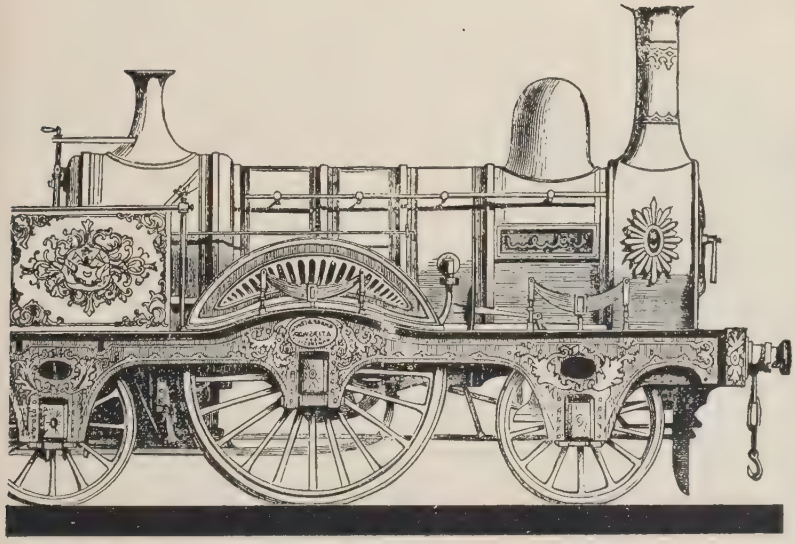
more on page 254

MARTIN
IS IN
THE NUCLEAR
BUSINESS





Current Martin Nuclear Division Programs:

Portable Packaged Power Plants

Plate, Tubular, & Ceramic Fuel Elements

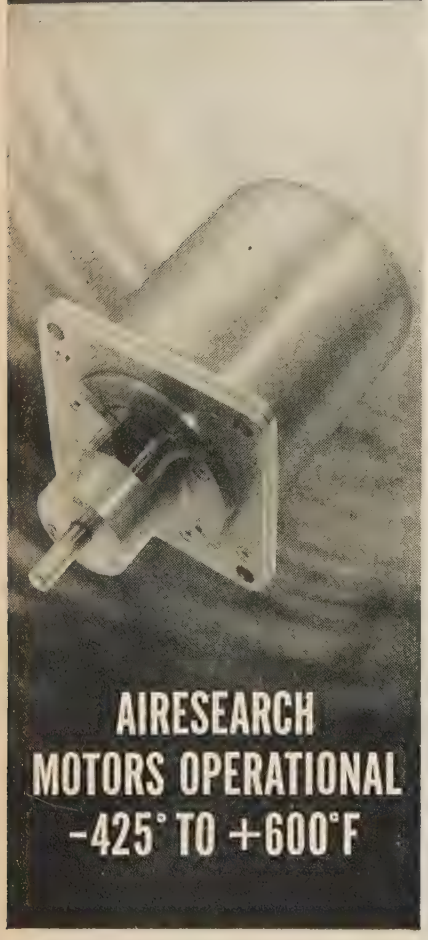
Liquid Fluidized Bed Reactor

Radionuclide Power Sources

MARTIN

The eight divisions of The Martin Company are Activation, Baltimore, Cocoa, Denver, Nuclear, Orlando, RIAS, and Space Flight.

Electromechanical Components and Systems Capability



AIRESEARCH MOTORS OPERATIONAL -425° TO +600°F

Specialized aircraft motors developed by AiResearch operate at temperatures from −425° to +600° F. ambient. The range of this compact, lightweight, ½ H.P. motor is −65° to +600° F.

AiResearch diversification and experience provide full capability in the development and production of electromechanical equipment and avionic controls for aircraft, ground handling, ordnance and missile systems.

A.C. and D.C. Motors, Generators and Controls • Inverters • Alternators • Linear and Rotary Actuators • Power Servos • Hoists • Electrical Pyrotechnics • Antenna Positioners • Positioning Controls • Temperature Controls • Sensors • Williamsgrip Connectors • Static Converters.

Your inquiries are invited.

THE GARRETT CORPORATION

AiResearch Manufacturing Division

Los Angeles 45, California

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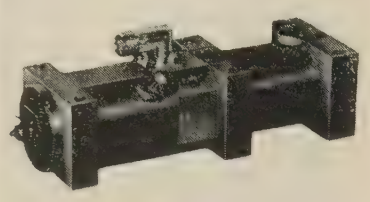
S-BAND PULSE OSCILLATOR weighs 20 oz



Model 306 S-Band pulse oscillator for microwave and radar systems has a power output of 1.5 kw peak minimum at 0.001 duty cycle, 1 microsec pulsewidth, 100 pps, says **ACF Industries, Inc., Avion Div., Dept. S/A, 11 Park Pl., Paramus, N.J.**

Vibration is listed at 20 g's, 20-2000 cps. It operates at temperatures from −50 to +100 deg C. Dimensions are: 6¼ in long, 2 in wide, and 1⅞ in high excluding connector.

Write in No 322 on Reader Service Card

RELEASE SWITCH has sealed lanyard

This sealed lanyard release switch is sealed to prevent icing from affecting its operation when lanyard pin is to be pulled. Designed specifically for drones at high altitudes, it features "no bind" lanyard pin to operate a double pole, double throw switch when lanyard pin is removed, says **Pendar, Inc., Dept. S/A, 14744 Arminta St., Van Nuys, Calif.**

Contacts are rated at 5 amps resistive. Diameter is ⅞ in.

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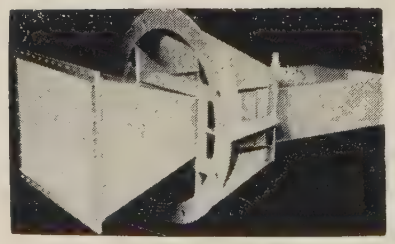
UHF HORN uses two frequencies



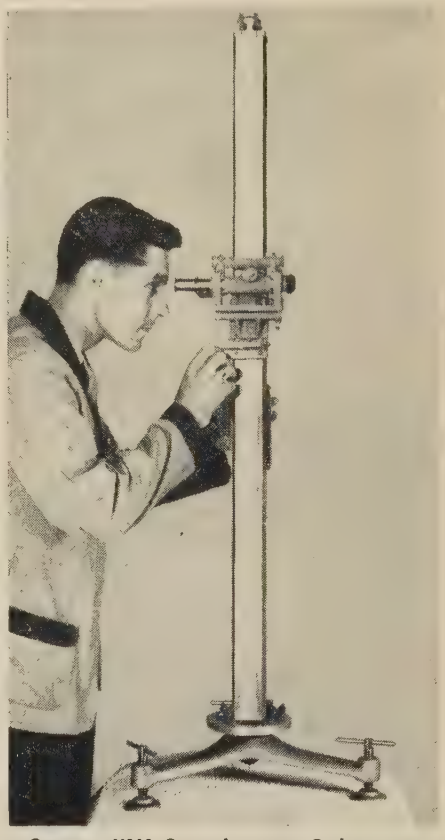
A UHF horn capable of operating at both the 400 and 650-mc region over narrow bands has joined the primary feeds made for radio telescope antennas by **The Gabriel Co., Dept. S/A, 135 Crescent Rd., Needham Heights, Mass.** Low VSR's and high power output without adjustment are features.

The horn is a primary feed for a 60-ft parabolic reflector. Input impedance is 75 ohms with a doorknob-type transition for coax to waveguide. The feed horn's mounting ring allows the horn to be oriented at zero, 45 and 90 deg. The horn will withstand an internal pressure of three lbs.

Write in No. 324 on Reader Service Card

more on page 250

Optical instrumentation for accurate measurement of remote or inaccessible objects



Gaertner M901 General-purpose Cathetometer

CATHETOMETERS

Gaertner Cathetometers are designed for accurate measurement of vertical distances or displacements. They are ideally suited for measuring where the object or action is remote or not accessible by ordinary means. Gaertner produces a wide variety of precision-constructed cathetometers to meet your individual requirements.

- **General-purpose Cathetometers**—These combine a high degree of accuracy with a maximum of convenience. Range 100 cm, focusing range 60 cm to infinity.
- **Precision Cathetometers**—For maximum accuracy and rigidity. Readings directly to 1 micron.
- **Micrometer Slide Cathetometers**—For precise measurement of short vertical distances. Range up to 4" or 100 mm. With telemicroscope, focusing range 12 cm to infinity.
- **Co-ordinate Cathetometers** — Permit making precise co-ordinate measurements on objects in a vertical plane. Focusing range 9" to infinity. Co-ordinate measuring range up to 24"x42".

SPECIAL PURPOSE PERISCOPES
REMOTE OPTICAL STRAIN MEASURING INSTRUMENTS

Write for Bulletin 162-56

The Gaertner Scientific Corporation

1270 Wrightwood Ave., Chicago 14, Ill.

Telephone: BUckingham 1-5335

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and this is the way the range is run:

OPERATION

On the Atlantic Missile Range, operation is precise execution. Here thousands of engineers and scientists, scores of corporations, and dozens of government and military agencies work together, in concert, to achieve significant advances in rocketry and astronautical exploration.

As prime contractor to the Air Force for operation of the Range, Pan American has for the last six years provided range planning, supply, maintenance, data collection and ground support engineering services – from test conception to critique – for this team and all its projects.

Throughout this period, the key to our strong capability has been the operational talent of the creative engineers and scientists comprising our technical management staff. At present, new technical investigations and responsibilities create unique opportunities for similarly talented individuals, particularly those experienced in electronics, quality control and facilities engineering.

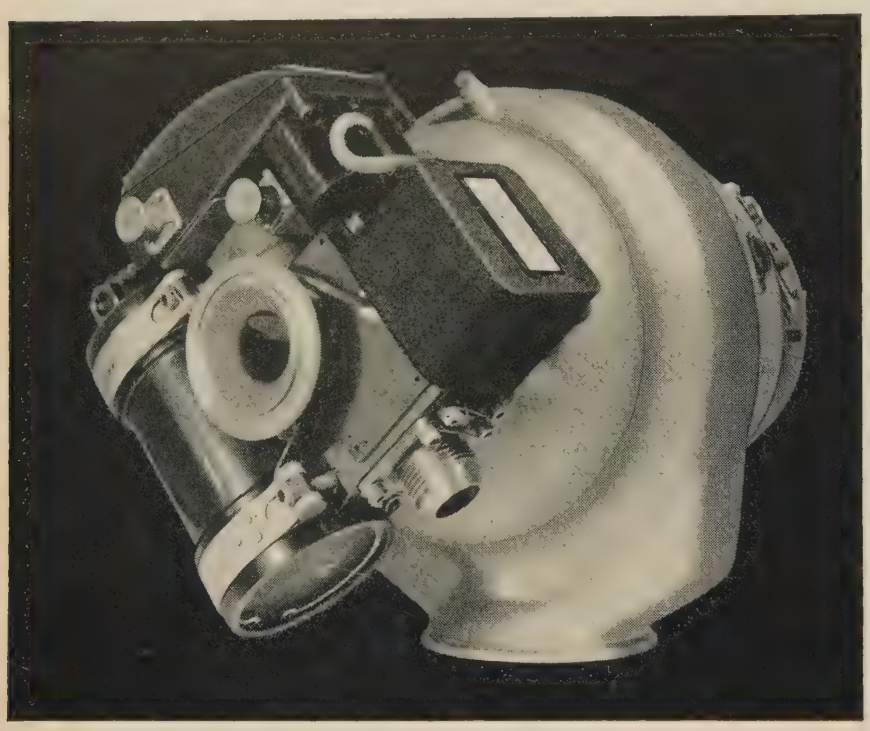
If you are one such man, we invite you to investigate these openings by addressing MR. J. B. APPLEDORN, *Director of Technical Employment*, Pan American World Airways, Inc., Patrick Air Force Base, Florida, Dept. T-11.

PAN AM

GUIDED MISSILES RANGE DIVISION · PATRICK AIR FORCE BASE, FLORIDA

Check Employment Inquiry Form on Page 195

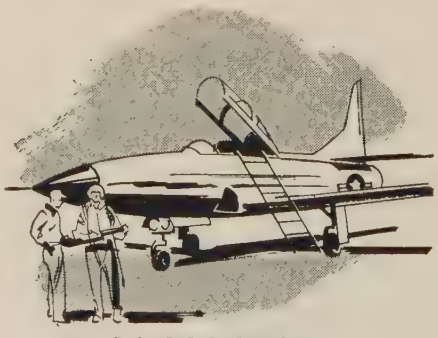
NEW BENDIX® FUEL-AIR COMBUSTION UNIT DOUBLES AS AIR-TURBINE STARTER!



Here's the newest state of the art in starter design—Bendix Utica Type 36E73-2A. It takes a mixture of compressed air and aircraft fuel and provides long-life starting capabilities for engines with high-energy starting requirements. Then, a simple movement of the selector switch allows air-turbine starting from the same unit by cross-bleeding compressed air from another engine to the turbine section of the starter.

A self-contained starting system, independent of outside support equipment, the new Type 36E73-2A also provides a two-start capability for each starter application—one start immediately following the other before a cooling period must be applied. The starter automatically locks in the start cycle, and automatically disengages from the engine after starting.

A new brochure outlines all the facts on the new Type 36E73-2A starter. Write Bendix Utica—leader in the field of jet-engine starters—for your copy.



21,000 BENDIX JET ENGINE STARTERS NOW IN SERVICE!

West Coast: 117 E. Providencia, Burbank, California
Canada: Aviation Electric, Ltd., 200 Laurentien Blvd., Montreal, Quebec
Export Sales and Service: Bendix International, 205 E. 42nd St., New York 17, N. Y.

Bendix Utica Division
UTICA, NEW YORK

Bendix AVIATION CORPORATION

Write in No. 181 on Reader Service Card at start of Product Preview Section

MICROWAVE ABSORBER has —40 db reflectivity

The Eccosorb CV is the first production microwave absorber guaranteed at a —40 db reflectivity level for the appropriate frequency band, says **Emerson & Cuming, Inc., Dept. S/A, 800 Washington St., Canton, Mass.** The material is available in six- and nine-in. thicknesses.

The six-in. absorber, CV-6, has a frequency range of 5.5 through 50 kmc, and the nine in., CV-9, a 2.5 through 50 kmc range. The material is a lightweight, flexible, fire-retardant foam product.

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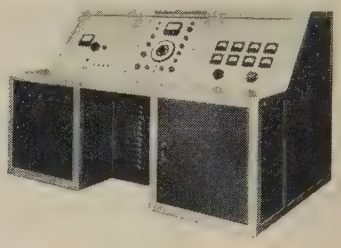
POWER AMPLIFIER for vibration testing



This 3-kw amplifier, designated model 5-151, has a distortion of less than 5% at full output. Noise and hum level is at least 40 db below signal level at full output, says **MB Electronics, Dept. S/A, 20 Fitch St., New Haven, Conn.**

It has an automatic power factor corrector and a 5-5000 cps wide band cycling oscillator with automatic acceleration and displacement control.

Write in No. 442 on Reader Service Card

SWITCH is low cost

Design simplicity, long life and high capacity for its size are featured in the 1901 Series momentary contact switch, says **McGill Mfg. Co., Inc., Dept. S/A, Valparaiso, Ind.**. Two precision wound stainless steel springs provide switching action on the 30-amp unit.

One spring returns the stem to normal position, and the other maintains pressure on the contacts. Vibration is absorbed to eliminate bouncing of the contact bridges and premature switch failure. The unit is available in spdt, spst (normally open or closed), and spst two-circuit models, and they may be stacked in any combination to make multiple pole devices. Electrical ratings include: 30 amps, 125 or 250 V ac, non-inductive; 25 amps, 125 or 250 V ac, inductive; two amps, 125 V dc; ½ amp 250 V dc; and one and two hp, 125 V ac and 250 V ac, respectively.

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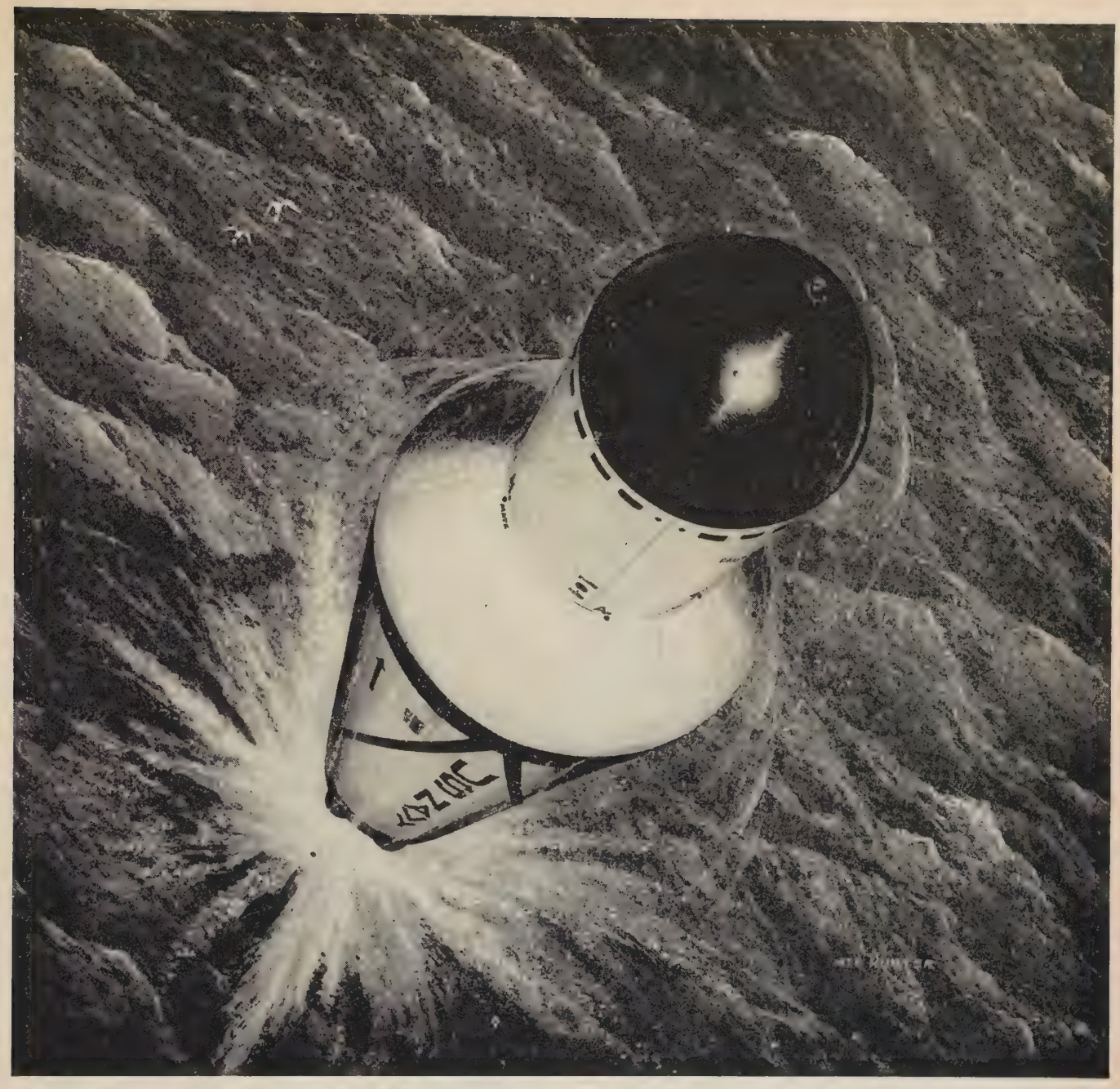
more on page 258



Project: **SALT WATER PUNCH**

Filter Application: **PROTECT HYDRAULIC CONTROLS**

Filter: **PUROLATOR**

The Polaris and the nuclear powered submarines which will carry and launch it form a mobile striking force that commands respect. Wherever they may be, it is imperative that, when the signal is given, the Polaris takes off and goes straight to the target.

Hydraulic control circuits play an important role in the programmed flight of the Polaris. To insure against malfunctions in the circuits, Purolator filters are designed as an integral part of many of them, to specifications set by Lockheed Missiles and Space Division, Polaris missile system manager.

Purolator engineers will gladly bring to your needs the filtration knowledge they provide for Polaris and other top-priority projects. A letter or phone call describing your aircraft or missile filtration requirements will receive prompt attention.

Filtration For Every Known Fluid

PUROLATOR

PRODUCTS, INC.

RAHWAY, NEW JERSEY AND TORONTO, ONTARIO, CANADA

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specify . . . G-E 125C TANTALYTIC* CAPACITORS

for high-temperature miniaturized electronic equipment in high-speed aircraft.

- Designed for operation in ambient temperatures from −55C to +125C at full rated voltage.
- Rated for full 2000-hour life at 125C with not more than 25% loss of initial capacitance.
- Available in plain or etched foil, with both polar and non-polar construction.

SPECIFYING INFORMATION on G-E's complete Tantalytic line is available from your nearest Apparatus Sales Office, or write for GEA-6258B, to General Electric, Section 449-14, Schenectady 5, N.Y.

*Registered trademark of General Electric Co.

GENERAL ELECTRIC

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STEEL TUBING is stainless

Small, cold-drawn tubing of PH 15-7 Mo, a new precipitation hardening stainless steel analysis which has excellent mechanical properties at room temperatures and outstanding ones at elevated temperatures, contains 14 to 16 per cent chromium, 6.50 to 7.75 per cent nickel, 2-3 per cent molybdenum and 0.75 to 1.50 per cent aluminum. The molybdenum increases the mechanical properties of the alloy at temperatures up to 1000 deg F, says **Superior Tube Co., Dept. S/A, Norristown, Pa.** It is hardenable with minimum distortion by low-temperature heat treatments.

In the heat-treated condition it is said to be extremely hard and strong. Its spring properties are similar to those of AISI type 301 stainless steel.

Write in No. 444 on Reader Service Card

BREAKAWAY CLAMP is remotely activated

A quick-disconnect breakaway clamp used to connect tubes carrying fuels and liquids between missile stages, and airplane wings and wing-tip tanks is adaptable to remote activation, says **Awica Clamp Div., Poly Industries, Inc., Dept. S/A, Pacoima, Calif.** The stainless steel clamps are ¾ in. wide and are available in diameters from 2½ to six in.

A lanyard, which can be solenoid-activated, may be attached to a hole provided in the clamp. The joints of the three-section device unhook when the lanyard is activated to release pressure on them.

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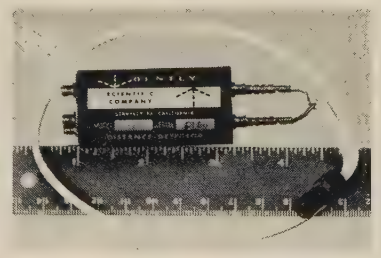
more on page 260

DISTANCE DETECTOR

This Distance Detector is a precision electro mechanical transducer which generates a dc voltage as a function of distance. It is an all transistor design to provide reliability, long life, and low energy consumption.



A very high sensitivity gradient and fast response make it a particularly precise and versatile unit for a vast variety of micro-distance measuring jobs.

OPERATION: This device senses distance to a conductive surface because of the variation of coupling coefficient as a function of distance from the face of a special coil to the conductive surface.

SENSITIVITY: 1000 volts per inch with H-1 sensing head
400 volts per inch with H-2 sensing head
200 volts per inch with H-3 sensing head

RANGE: 10, 25 and 50 thousandths of an inch, with head types 1, 2, and 3 respectively.

RESPONSE: Flat from dc to a single lag at 50,000 cps.

SUPPLY: 12 vdc at 2ma

SIZE & MASS: 1.2" diameter x 2.5" long, 80 grams

COST: Model 15, $72.00 with H-2 head. Additional standard heads $6.00 each.

USES: Typical uses are control of location and indication and measurement of dimension, displacement, deflection, velocity, vibration, contour, creep, and counting.

BENTLY SCIENTIFIC COMPANY

High speed proximity relaying attachments also available.

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...from any angle

All-Angle Work INSPECTION MIRRORS by ULLMAN

NEW! All models now supplied with **INSULATED** vinyl plastic.

NEW! Exclusive non-rotating inner hex rod on telescopic models prevents mirror from swinging out of alignment.

Heavily chrome-plated; precision-made.

NEW! Thumb RATCHET MIRRORS • Adjustable • Practical • Precision-engineered • Handles easily • Locks at any angle between 90° and 180°.

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ULLMAN DEVICES CORP.
RIDGEFIELD, CONN.

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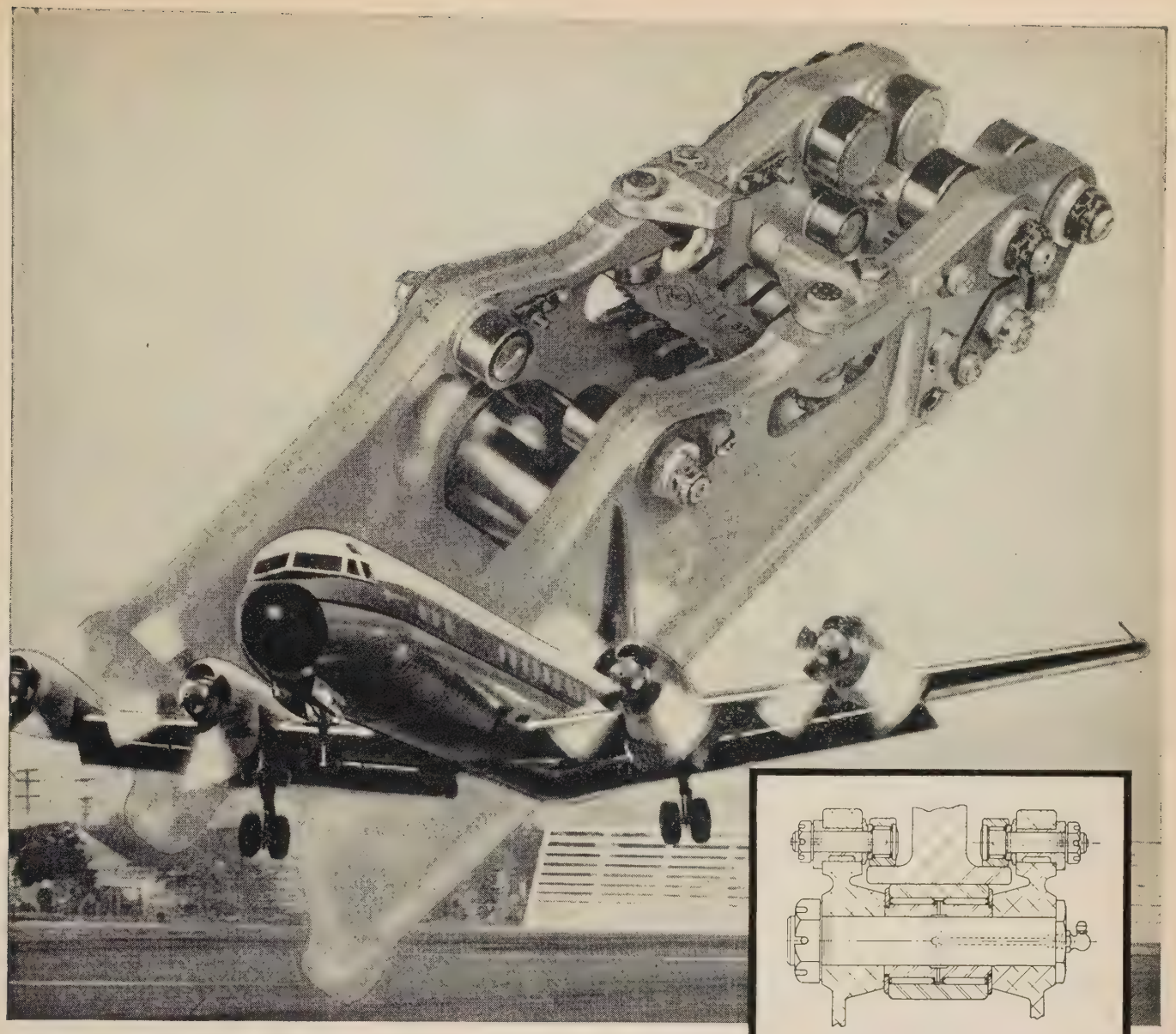
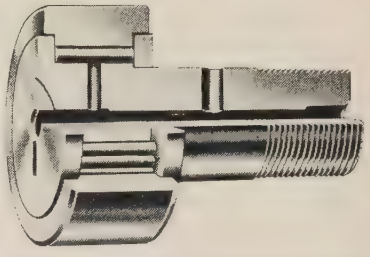


Track roller assembly used on Lockheed Electra (shown in photo above), as well as the C 130-A and Super Constellation, incorporates eight Torrington RT Cam Followers and three Torrington NBF Needle Bearings as track rollers. Portion of assembly is illustrated in above drawing.



Flightweight "champs" of the world...

Torrington Cam Followers

Every fraction of excess weight and size is engineered *out* of the Torrington Type RT Cam Follower to suit it especially for airframe applications.

Designed to run on a hardened steel track, the RT outer race is narrower than that of a standard cam follower needle bearing. The full complement of small diameter rollers assures maximum radial capacity and minimum starting and running friction. The Type RT Cam Follower is mounted with a standard tension nut, and the Type RS with a standard shear nut. All features conserve weight and space.

Type RT and RS Cam Followers are also available in stainless steel for exposed airframe applications. Design, materials, heat treat and finishes meet the highest standards in industry. For further information or application assistance, consult Torrington's engineering department. **The Torrington Company, Torrington, Conn.—and South Bend 21, Ind.**

TORRINGTON BEARINGS

District Offices and Distributors in Principal Cities of United States and Canada

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THE S. S. White Industrial Airbrasive® Unit

It may seem a Scrooge-like trick to slice up this Christmas decoration, but we think you will agree that it is a good demonstration of the ability of the Industrial Airbrasive Unit to cut fragile, brittle materials.

This unique tool is doing jobs that were up to now thought impossible. A precise jet of abrasive particles, gas-propelled through a small, easy-to-use nozzle, cuts or abrades a wide variety of materials such as germanium, fragile crystals, glass, oxides, ceramics, and many others.

Use it to make cuts as fine as .008"... or remove surface coatings without affecting base material... wire-strip potentiometers... deburr precision parts... adjust printed circuits... in the laboratory or on an automated production line.

Important too: *the cost is low*... for under $1,000 you can set up your own Airbrasive cutting unit!

Send us your most difficult samples and we will test them for you.

1096

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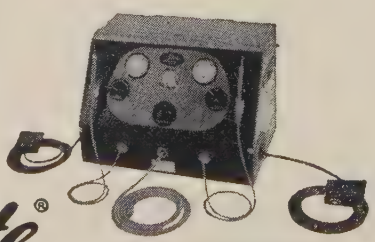
...complete information



New dual Model D!

S. S. White® INDUSTRIAL DIVISION • Dept. 21A • 10 East 40th Street, New York 16, N. Y.

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RUBBER PARTS in very small sizes

Rubber bushings as small as .050 in. od by .050 in. high, and with a center hole of .012 in., are among the very small synthetic rubber parts being mass-produced by **Industrial Electric Rubber Co., Dept. S/A, 31945 Aurora Rd., Solon, O.** Compounds for these components use a wide range of elastomeric materials, and they are carbon- and sulphur-free to permit use in thin insulating and gasketing applications without risk of current leakage, silver tarnish, or outgassing.

Parts made of fluoropolymer Kel F Elastomer are most useful for applications where resistance to acids is of paramount importance. Those made of Viton A, another fluoropolymer, are suggested for use where resistance to high temperatures, ozone, abrasion and radiation is important. Kel F has a tensile of 3100 psi, a Shore hardness of 67, and a dielectric strength of 770 V/mil. Viton A's tensile is 1500 psi, hardness is 77, and dielectric strength, 600 V/mil.

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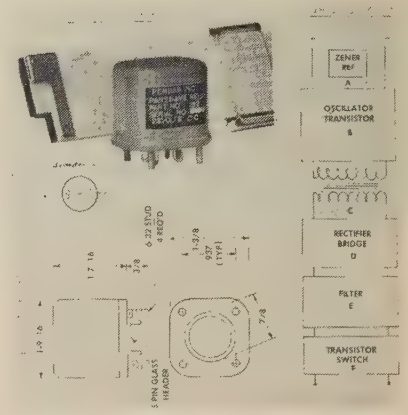
ELECTRONIC RELAY has no moving parts



This electronic coil circuit of these electronic relays operates on 28 volts d-c, pull-in at 18 V and drop out at 11 V, or less, with positive snap-action characteristic. The coil circuit is completely isolated from the electronic switching circuit, making one coil circuit capable of switching many independent circuits within one unit, says **Pendar, Inc., Dept. S/A, P.O. Box 3355-T, Van Nuys, Calif.**

Available in 6 basic units, capable of switching from 10 mils to 10 amp in both SPST N.O. and DPST N.O. configuration, the relays are complete potted and will withstand most shock or vibration problems present in today's designs. The unit will switch either ac or dc, and has a transfer time of less than 50 microsec and no contact bounce.

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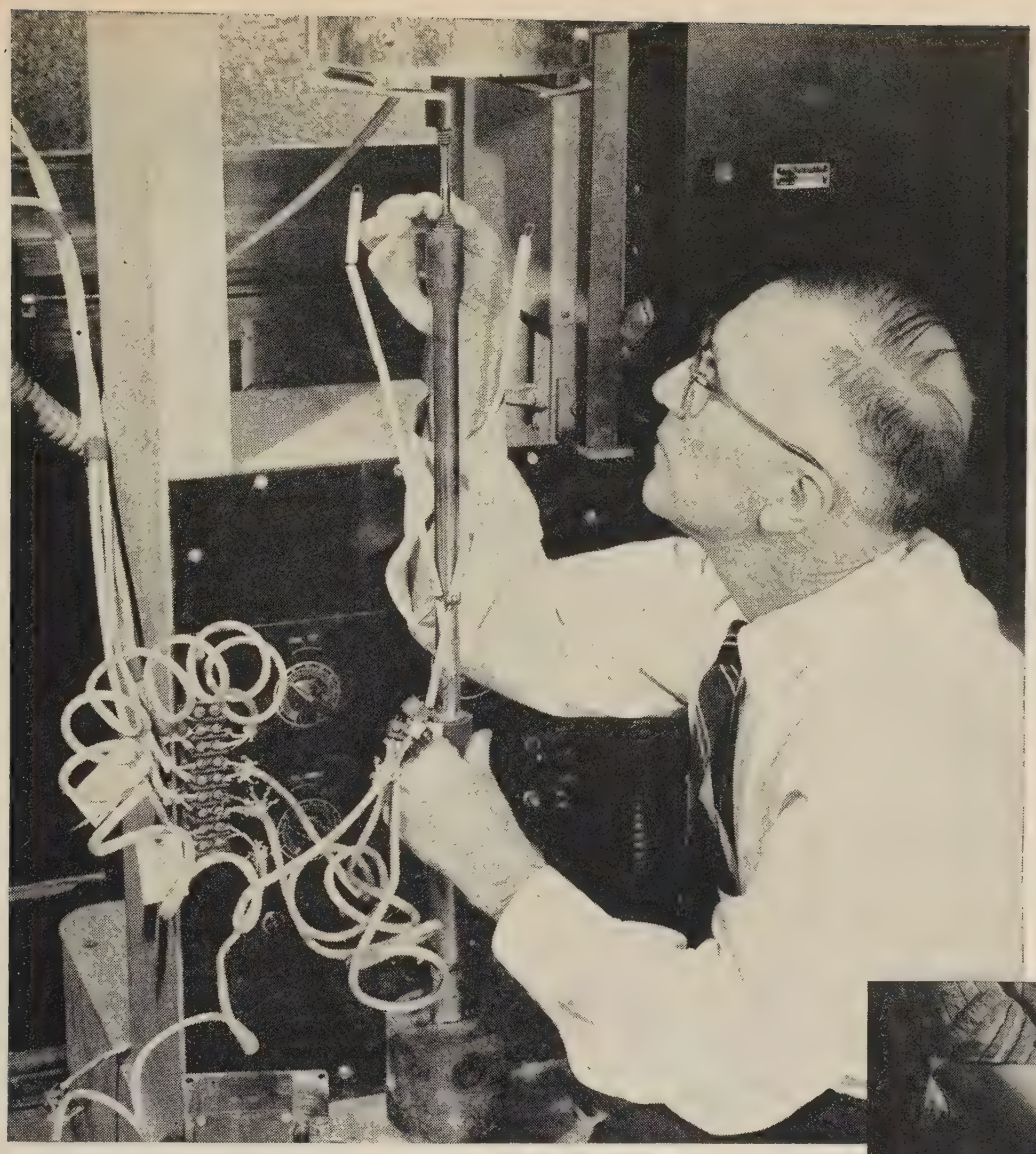
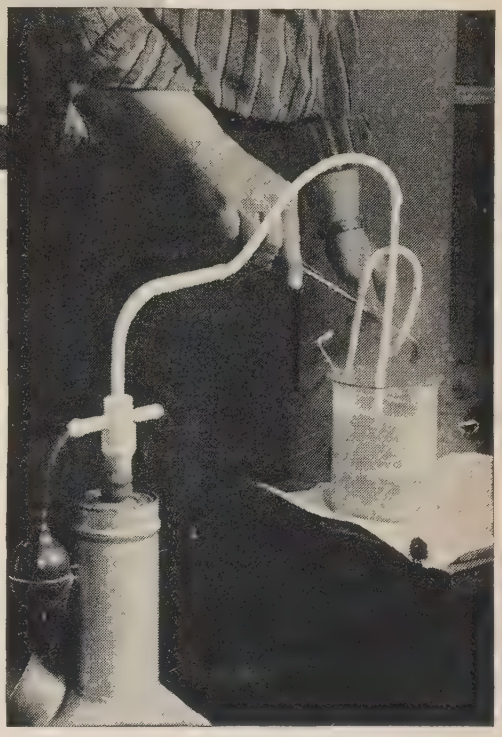
more on page 262



Physical tests at Standard include those for special properties of steel alloys under extreme variations in temperature. Here, the strength and ductility of steel are being checked for resistance to stress under severe conditions of elevated temperatures over a prolonged period of time.

Charpy impact and transition temperature determinations have recently assumed importance in many applications. Here a steel sample is immersed in liquid nitrogen to determine its susceptibility to fracture at temperatures as low as —300°F.



Quality control—a vital activity at Standard Steel Works

Every conceivable shop and laboratory test required for modern quality control can be performed by Standard's staff of metallurgical technicians. Testing of incoming raw materials; physical property tests of steel and other alloys at temperatures from several hundred degrees below zero up to red heat; gas analysis, ultrasonic, X ray, magnetic particle, fluorescent penetrant and microscopic examination of finished products are routine checks which assure that the finished, delivered product will meet the most rigid specifications. Write Department 6-L for full details.

Standard Steel Works Division

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AiResearch expansion in electronics and electromechanical activity is creating outstanding positions at all levels for qualified engineers.

INSTRUMENT DESIGN

Electromechanical design of force-balance instruments, pressure measuring devices, precision gear trains and servo-driven positioning devices. Experience in electrical and electromagnetic transducers desirable.

Openings also exist in the following areas: Flight Systems Research ... Controls Analysis ... Data Systems Research ... Flight Data Components ... Airborne Instrumentation Analysis and Design ... Electromagnetic Development.

Send resume to: Mr. Robert Richardson

THE GARRETT CORPORATION

AiResearch Manufacturing Division

9851 So. Sepulveda Blvd., Los Angeles 45, Calif.

Check Employment Inquiry Form on Page 195

ROTARY SWITCH has up to 48 circuits

This rotary switch for aircraft, missile and ground control equipment, type R-8, is a compact unit which allows up to 48 circuits that may be switched with a 6-section configuration. It uses a contact roller which is driven independently of the operating shaft at high speed making a fast break and make, according to **Standard Electrical Products Co., Dept. S/A, Costa Mesa, Calif.** Switching action takes place within the enclosure.

Contact rating at 28 vdc or 115 vac; continuous 25 amp. resistive 25 amp. Inductive 15 amp. Overload. 50 amp. Maximum switching per section: 1 pole, 8 position, 8 circuit; 2 pole, 4 position, 8 circuit.

Write in No. 448 on Reader Service Card

ALUMINUM ALLOY for missile castings

MA-356 is a high-purity, aluminum alloy that is expected to contribute weight-saving efficiencies in sand and permanent mold castings for missiles and high-performance jet aircraft, says **Rolle Mfg. Co., Dept. S/A, 3rd & Cannon Aves., Lansdale, Pa.** The new material is highly responsive to heat treatment, and specific physicals can be emphasized by careful control of heat treatment procedures.

Missile castings that have been poured in this alloy have exceeded the physicals specified in MIL-C-21180A. In the T-6 condition, ultimate tensile strength can be controlled within 40,000 to 50,000 psi, yield strength within 30,000 and 40,000 psi, and elongation within two to five per cent. Significantly higher physicals have also been achieved.

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more on page 264

Taber

TELEFLIGHT®

MODEL 180

AIRBORNE PRESSURE TRANSDUCER

Approximately 3½" long and 10 ounces in weight. The rugged construction of Model 180 makes it the ideal Transducer for airborne applications. BONDED STRAIN GAGE construction results in low sensitivity to vibration or shock in any axis. Proving ring acts as a heat-sink for the strain gages under zero gravity conditions. Resolution is INFINITE. Features standard built-in pressure overload protection. Pressure Ranges: 0-350, 0-750 and 0-1,000 PSI. Linearity 0.3%, Hysteresis 0.25% of F.S. at any given point, Ambient Temperature —100° F. to +2.75° F.

Write for literature on Miniature Transistor Amplifiers which were specially developed for missile and rocket applications.

Write or telephone for literature and prices.

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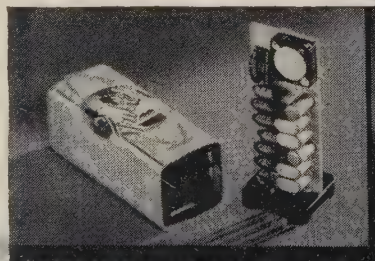

MODEL 196G TRANSISTOR AMPLIFIER

MODEL 214 TRANSISTOR AMPLIFIER

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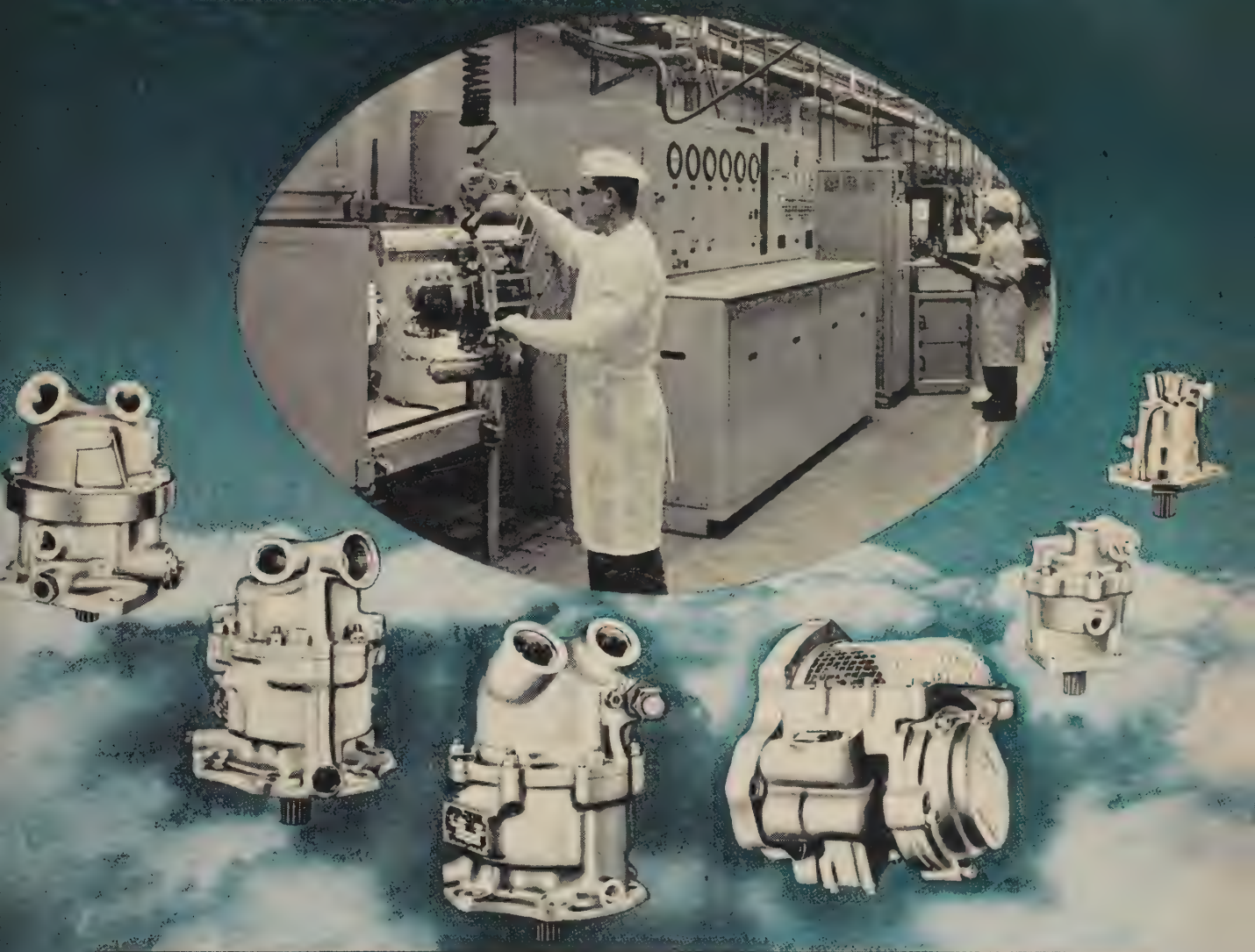
Standard HYDRAULIC PUMPS

FOR FLUID TEMPERATURES TO 400°F • LOWEST WEIGHT / DISPLACEMENT AND LOWEST WEIGHT / HORSEPOWER RATIO AT RELIABLE SPEEDS



Variable Displacement			Rated			Maximum			Envelope	
Models	Cu. In./Rev.	Weight	R P M	G P M	LB/HP'	R P M	G P M	LB/HP'	Diameter	Length
Forged Aluminum Housings for Fluid Temperatures to 400°F.										
P175	1.75	15.5	4500	33.0	.269	6000	44.4	.200	5.75	8.32
P105	1.05	11.5	5500	24.0	.274	8000	35.4	.185	5.25	7.25
P65	.65	8.1	6000	16.2	.286	9000	24.6	.188	4.66	6.00
P56	.568	8.1	7000	16.5	.281	10000	23.9	.194	4.66	6.00
P16	.163	3.5	12000	8.0	.250	16000	10.8	.185	3.50	4.75
P11	.115	2.6	12000	5.7	.261	16000	7.7	.193	3.25	4.47
*Stainless Steel Housings with No Increase in Weight										
*P064	.064	2.1	12000	3.1	.388	18000	4.8	.250	2.125	3.35
*P044	.044	1.8	12000	2.15	.479	18000	3.3	.312	2.000	3.06
'Pump Weight/Hydraulic Horsepower at 3000 PSI										

SMALL SIZE AND SYMMETRICAL DESIGNS FOR EASE OF INSTALLATION. • FEWER PARTS DESIGNED FOR MAXIMUM RELIABILITY. • STAINLESS STEEL HOUSINGS FOR TEMPERATURES ABOVE 400°F. • STANDARD PUMPS FOR SYSTEM PRESSURES TO 4000 PSI. • CUSTOM DESIGNS FOR INTEGRATION INTO SUBSYSTEMS. • FIXED DISPLACEMENT MODELS WITH CORRESPONDING WEIGHT REDUCTIONS. • TESTING IS IN PROGRESS FOR TEMPERATURES ABOVE 550°F. • FOR ORIGINAL EQUIPMENT, REPLACEMENT OR FUTURE PLANNING . . .

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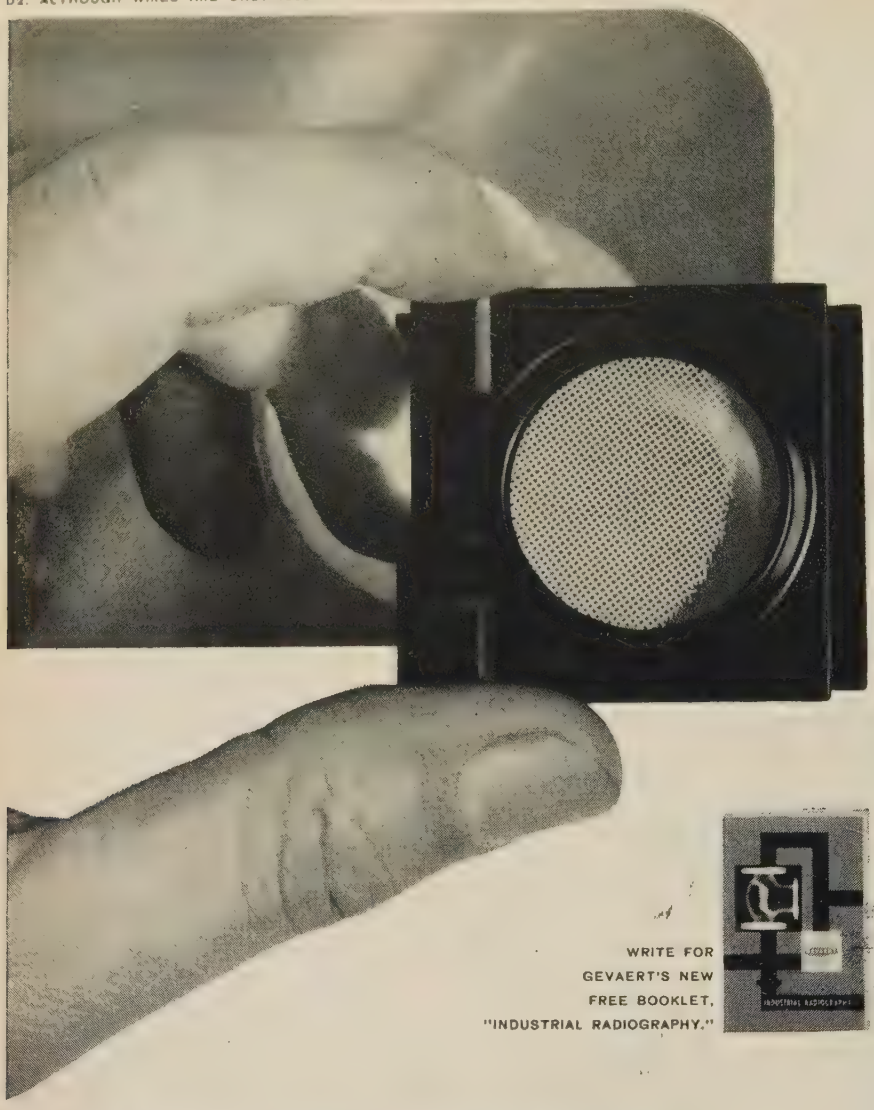
MAGNIFIED SECTION OF TIGHT-MESH SCREENING (100 WIRES PER INCH) AS X-RAYED ON GEVAERT STRUCTURIX D2. ALTHOUGH WIRES ARE ONLY .008" APART, NOTE SHARP DELINEATION MADE POSSIBLE BY THIS FILM.



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GEVAERT STRUCTURIX D2
for the most searching look in radiography

Structurix D2, the ultimate in X-ray films, is specifically designed for the examination of thin or medium thick sections of light metal. Its exceptional contrast, ultra fine grain and high resolving power record the minute details that other films miss. ■ D2 is proving its quality in critical defense applications. In the radiography of nuclear fuel elements, for example, it has been responsible for major advances. Previously, examining fuel tapers with ordinary X-ray films provided limited accuracies of ±20 to 30 mils. With Structurix D2, however, accuracies of ±10 mils have been consistently achieved, permitting users to see more of the tapered fuel core than ever before, even where radiographic object contrast between core and outer structure was extremely small. ■ For the most searching look in radiography, therefore, always specify Gevaert Structurix D2.

THE GEVAERT COMPANY OF AMERICA, INC.
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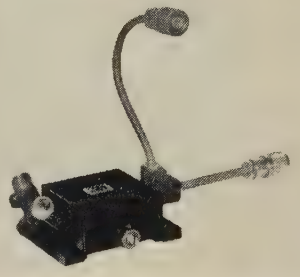
DETECTOR measures attack angle

Greater torque for its self-powered null-seeking probe is one of the improved characteristics featured in this new-type ADD-RL airstream direction detector, says **Specialties, Inc., Dept. S/A, Skunks Misery Rd., Syosset, N.Y.** The device measures and transmits angle of attack or side slip data.

The probe is strengthened to minimize damage in handling and a heater provides for adequate de-icing under the most severe conditions. The unit is supplied with up to a 60-deg range of rotation, and it is calibrated to ±0.1-deg. accuracy.

Write in No. 260 on Reader Service Card

S-BAND FILTER weighs 12 oz



This S-Band microwave filter is designed for use in radar system applications. It has tuneable range in excess of 300 mcps and is available with non-tuneable mixer and diplexer units, says **ACF Industries, Inc., Avion Div., Dept. S/A, 11 Park Pl., Paramus, N. J.**

Insertion loss is less than 1.5 db for a 15 mcps bandwidth. Input and output is less than 1.5. Dimensions are: 2 in long, 3 in wide and 1¼ in high. Single tuning with locking or individual tuning is optional.

Write in No. 261 on Reader Service Card

POWER SUPPLY is low cost

A novel transistor packaging technique permits the SE Series of power supplied to attain a 36 W output with germanium transistors, thus reducing the cost substantially, says **Mid-Eastern Electronics, Inc., Dept. S/A, 32 Commerce St., Springfield, N.J.** Each of the four power transistors, which are used in parallel, are mounted in one side of the cast, finned housing for maximum heat dissipation.

The supply is rated at 12 V, zero to three amps, continuous duty. Voltage regulation is +0.1 per cent for both line and load, and ripple is two mv, peak-to-peak. The power supply is designed for use in a cooled area, but can be operated for moderate periods without cooling in an ambient of 105 deg F.

Write in No. 262 on Reader Service Card

more on page 266

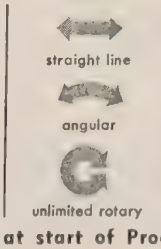
How to remotely synchronize valves in a temperature range of −100° to 1200°. Or . . .

. . . how to reduce weight of a remote control system by 54%-60%, space by 90%. Or, run controls in pressurized areas without affecting conditions. Or, get precision response never possible before . . . with a system that is 95% efficient in a 90° bend.

The "how" is with TELEFLEX® . . . the "why" is the exclusive TELEFLEX helix wire cable design. No remote control cable anywhere gives such high sensitivity and response . . . such a reduction in weight and backlash . . . such design freedom with straight line, angular *and* unlimited rotary motion!

The technical advances made possible with TELEFLEX cable mean that TELEFLEX engineers have gone further and can offer *more* in the development of complete mechanical control systems for any purpose. Write today . . . for catalog, or help on your specific problem. TELEFLEX Incorporated, North Wales, Pennsylvania.

TELEFLEX SYSTEMS offer unequaled design flexibility because they are the only systems to offer all three types of mechanical motion...



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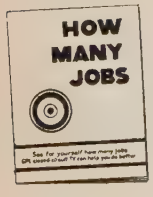
worm's-eye view of a missile

taking off with bone-jarring impact is studied safely at closest range through GPL closed-circuit television.

How many jobs could GPL Industrial TV help you do better?

You'll never know until you investigate! You'll be amazed at the versatility, simple operation, and low cost of Industrial TV systems by GPL, one of the world's leading manufacturers of industrial, military and broadcast TV.



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GENERAL PRECISION LABORATORY INC.
PLEASANTVILLE, NEW YORK

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ANCHOR NUTS are lightweight

These "weight master" anchor nuts are said to average 23 per cent less in weight and to meet National Aircraft Standards. The balanced design is achieved by removal of excess metal without any sacrifice in full performance, according to **Voi-Shan Mfg. Co., Dept. S/A, 8463 Higuera St., Culver City, Calif.** They comply with industrial-military specifications.

They cover single lug, two lug, and corner types. Five sizes available, 4-40 through ¼-28.

Write in No. 452 on Reader Service Card

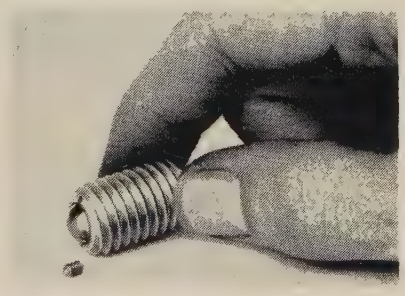
GEAR MOTOR has double shaft

This double shaft gear motor is driven by a 200 vac 400 cycle 3-phase motor. Various speeds and torques can be made available for custom requirements by various different types of gear sets, says **Western Gear Corp., Dept. S/A, 132 W. Colorado Blvd., Pasadena, Calif.**

Typical speeds are: 1700 rpm at 96 oz. in. of torque on one shaft, and 4700 rpm at 650 oz. in. torque on the opposite shaft.

Write in No. 453 on Reader Service Card

BALL PLUNGERS in miniature sizes



These miniature ball plungers, sizes 10-32 and ¼-20 are said to be particularly useful in instrumentation, electronics and missile work. Standard balls are made of type 440 hardened stainless steel, says **Vlier Engineering Corp., Dept. S/A, 8900 Santa Monica Blvd., Los Angeles 46, Calif.**

Balls are made of high carbon chrome alloy, K-monel, aluminum, tobin bronze, carbon steel, glass, nylon, carbides, copper and other special materials.

Write in No. 454 on Reader Service Card

MODULATION TEST SET has dual function

Both frequency and voltage modulation of aircraft and ground power 400-cps systems can be measured with the direct-reading Model T97 modulation test set, says **Avtron Mfg., Inc., Dept. S/A, 10409 Meech Ave., Cleveland 5, O.** The portable, accurate device, equally useful in field or laboratory, also provides data on stability and transients.

The unit is designed for self-calibration and has separate oscillograph c outputs for simultaneous recording of both frequency and amplitude modulation. Recorder outputs will drive high-frequency galvanometers without further amplification. Voltage modulation is ±0.05 per cent on the 0.5 per cent scale and ±0.13 per cent on the 2.5 per cent scale. Frequency modulation is ±0.025 per cent on the 0.25 per cent scale and ±0.062 per cent on the 1.25 per cent scale.

Write in No. 263 on Reader Service Card

MAGNETIC AMPLIFIER has response to 50cps

Model 405 precision magnetic amplifier is designed to drive electro-hydraulic servo valves. A special feature of the unit is its response characteristic to 50 cps which permits it to be used in critical response systems, says **Acromag Inc., Dept. S/A, 22519 Telegraph Rd., Detroit 41, Mich.**

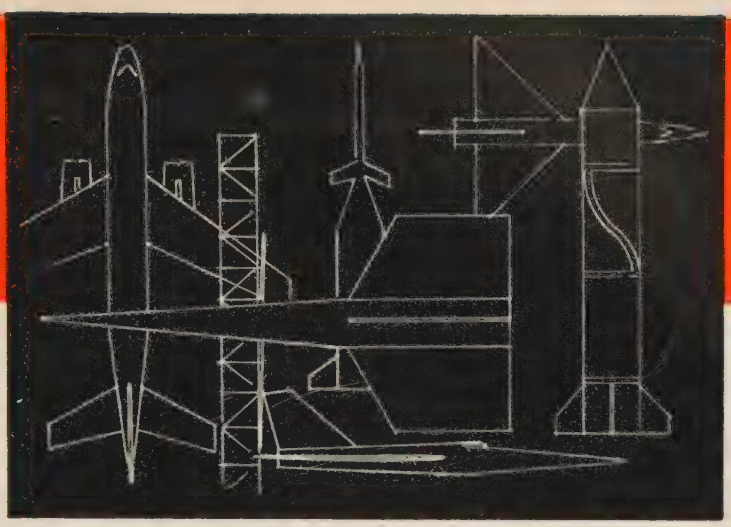
The amplifier requires less than 3.0 watts of 115 V 400 cps power and weighs less than 9.5 oz. It will withstand temperatures of up to 125 deg C and shocks of 100 G's. The unit is hermetically sealed in a self-contained plug-in package.

Write in No. 264 on Reader Service Card

more on page 270

"BECCO Hydrogen Peroxide has met all performance requirements"

—reports General Electric Company's Flight Propulsion Laboratory Department



Sure, we at Becco know all the advantages of our high-strength Hydrogen Peroxide—and so do our customers. But we wanted a way to tell a lot more people—so we asked GE if they would give you their comments on our H_2O_2. Here's what they said:

"1. Becco has met all our delivery requirements for hydrogen peroxide regardless of the size of the order.

"2. Deliveries have never failed to meet our specifications.

"3. The hydrogen peroxide delivered has met all performance requirements. Our decomposers have never failed due to trace elements in the peroxide. Our decomposers have run 67,000 seconds at a fuel rate in excess of two pounds per second without malfunction.

"4. Storage requirements have been exceeded in all cases."

A few more facts: Becco H_2O_2 is a stable liquid over a wide range of temperatures. Its high density reduces space requirements per unit weight. Its ease of catalytic and thermal decomposition makes for simple and reliable systems.

Write today for free samples and our newest Technical Bulletin (No. 93), "Anhydrous Hydrogen Peroxide as a Propellant". Address: Dept. SA-8.

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Becco Chemical Division
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FMC CHEMICALS INCLUDE: BECCO Peroxygen Chemicals • WESTVACO Phosphates, Barium and Magnesium Chemicals • WESTVACO Alkalis, Chlorinated Chemicals and Carbon Bisulfide • NIAGARA Insecticides, Fungicides and Industrial Sulphur • OHIO-APEX Plasticizers and Chemicals • FAIRFIELD Pesticide Compounds and Organic Chemicals

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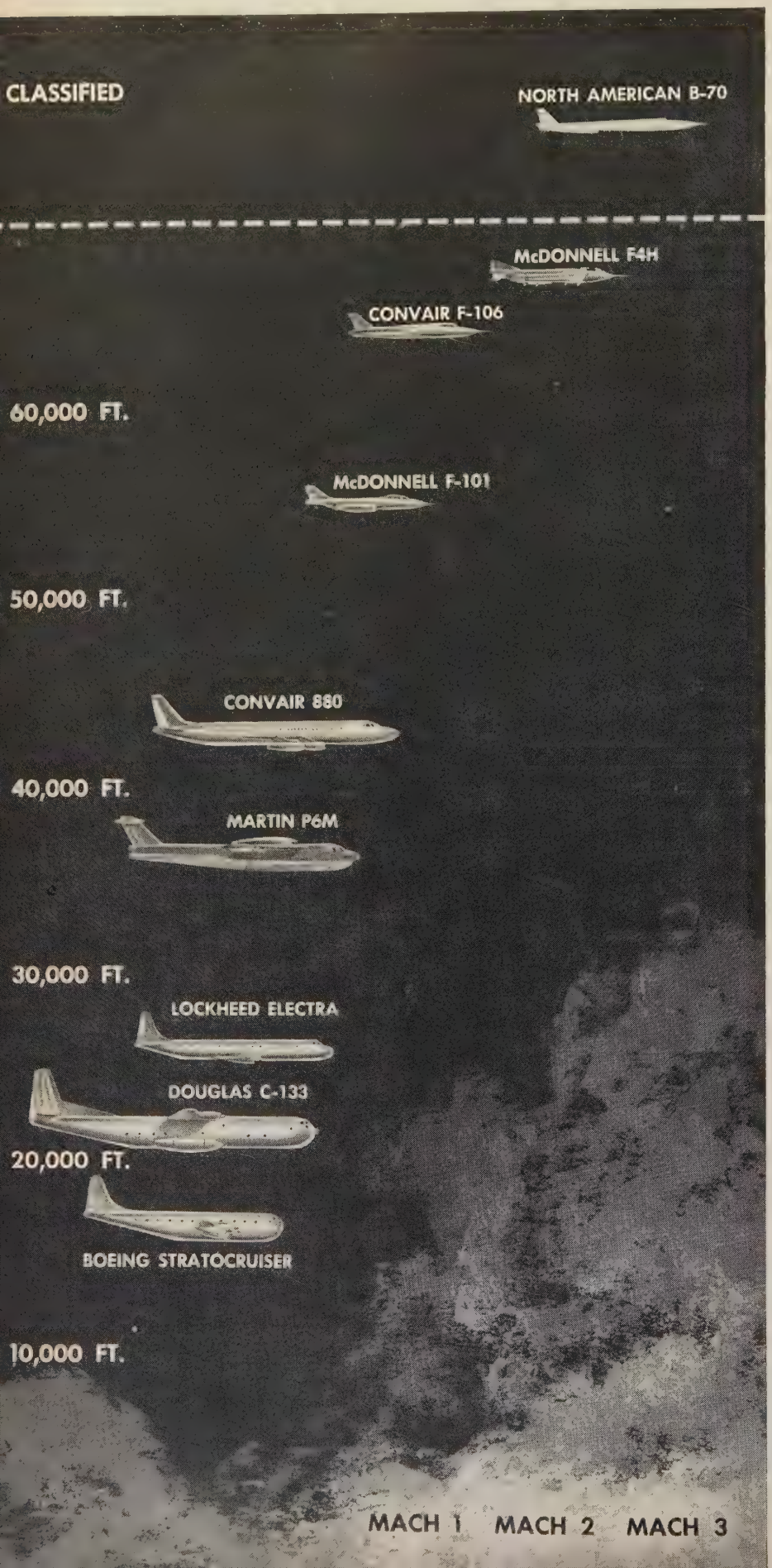
CONTINUED LEADERSHIP IN SECONDARY POWER EQUIPMENT



General generating

General Electric has been selected to supply the advanced-design secondary electrical power generating system for the North American B-70 Valkyrie, the Air Force's new MACH 3 multi-purpose bomber.* Designed for supersonic high-altitude operation with inherent long-range flight endurance and large load-carrying capability, the B-70 can be adapted to offense, defense, reconnaissance, or special airlift missions.

The new, specially designed G-E system consists of an Inductor-Lundell generator, controlled-rectifier regulator, and protective panel. The revolutionary generator, newly applied to aircraft systems, will provide extreme system reliability by eliminating normally required brushes, slip rings, commutators, rotating windings, and rotating rectifiers.

Development of this system for MACH 3 aircraft offers a challenge never before encountered in manned aircraft. New lubricating and insulating methods and new sturdy, compact construction are needed to stand flight stresses three times the speed of sound at altitudes previously unreached by operational aircraft.

Some equipment will be required to withstand temperatures of 600 F, vibration input of 15 g's (as much as 60 g's locally), and shock of 20 g's. Extreme reliability is, of course, a must.

In developing this equipment, General Electric is using experience and knowledge derived from the material and component development phase of a separate Air Force High-temperature (HOTELEC) Program under subcontract from North American Aviation. G.E.'s completely equipped research and manufacturing facilities are ideally suited to develop and produce advanced systems like HOTELEC and the B-70. And, G-E leadership in secondary power equipment extends through 40 years and more than 50 different aircraft.

*Sundstrand Aviation is manager of the B-70 secondary power system for North American Aviation, Inc.

Aircraft pictured represent only a few of those for which G.E. has developed secondary power-generating systems.

Electric's new concept in aircraft systems is awarded B-70 contract

Design Concept

Design innovations in the new G-E generating systems will provide outstanding results in these areas:

• **Reliability**—Key to the increased reliability of the G-E system, is the revolutionary Inductor-Lundell generator. Field windings and rectifiers will be located in the stator instead of the rotor as in conventional machines. Lower component temperatures result from shortening heat-transfer paths between windings and coolant.

In addition, all available control components—relays, transistors, magnetic amplifiers, controlled rectifiers, capacitors, and resistors—were fully evaluated as to performance and reliability. Then exhaustive research—speeded by computers—was conducted on individual circuits of each system to determine the combination of components which would provide maximum reliability and minimum weight for each particular application.

• **Electrical configuration**—It is planned that the B-70 system will consist of four 60-kva generators in parallel for main and emergency power. Through careful system designing, there will be a precise integration of generators with necessary control, regulating, and protective components.

• **Light weight**—Unnecessary weight will be eliminated by (1) combining Inductor and Lundell generator principles, (2) utilizing the generator frame as flux path, (3) use of more efficient magnetic material in the frame, and (4) integrating bearing and cooling and lubricating systems with the Air Vehicle Sundstrand Drive.

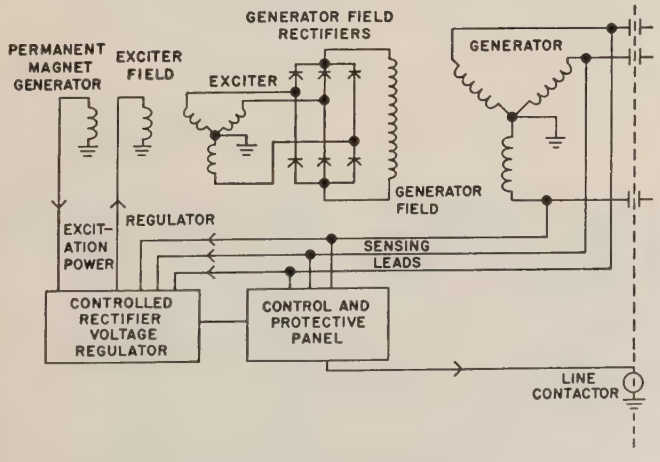
Weight also will be saved in another way. In analyzing the complete B-70 system, North American electrical engineers felt that the long feeder runs from generator to load offered an excellent opportunity to evaluate a variety of generator voltages, feeder sizes, and transformer designs to determine the optimum combination. Coordination with General Electric indicated the practicability of such a design breakthrough. As a result, it was decided that power will be generated and transmitted at 240/416 volts and stepped down to 115/200 volts at the load by novel transformers designed specifically for this application. A net weight saving to the aircraft of hundreds of pounds was thus accomplished together with improvement in electrical transmission and cooling efficiencies.

Future Application

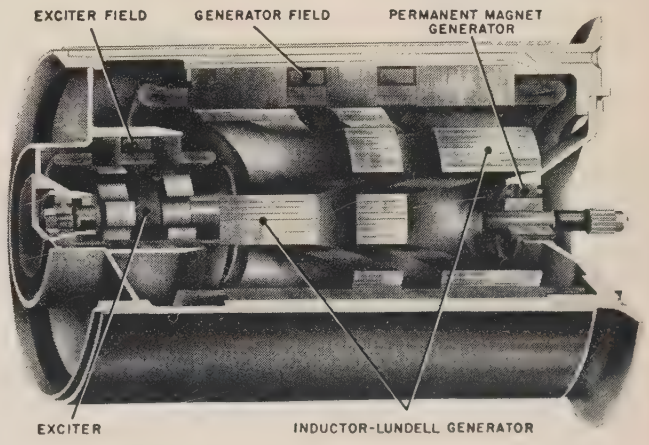
General Electric research on this system holds bright promise for future applications. Further development will make similar systems available in many future ratings and sizes for other types of aircraft. For more details, contact your General Electric Aviation and Defense Equipment Sales Office or write Section 796-1, General Electric Company, Schenectady 5, N. Y.

Progress Is Our Most Important Product

GENERAL ELECTRIC



This elementary schematic diagram shows the arrangement of generator and control components.



Cross-sectional view of the Inductor-Lundell configuration of the secondary power system generator.

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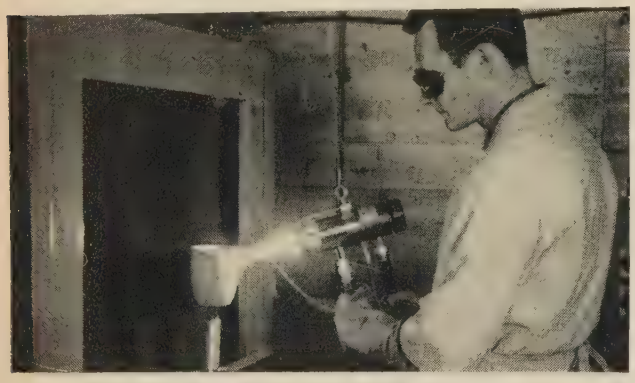
NOW— PLASMA FLAME SPRAY IN YOUR OWN PLANT

Apply coatings of high melting point materials such as tungsten, tungsten carbide, molybdenum, chromium carbide, titanium oxides, calcium zirconate, rare earth oxides. Operates at 10,000°-15,000°F.



Plasma flame spraying hi-temperature crucible

Now any material that can be melted without decomposing can be sprayed. Despite high melting temperature, object sprayed stays cool.

High fluidity of particles and high velocity of impingement bond the particles together to produce high density coatings semi-fused to work. Absence of air eliminates oxidation.

The METCO Plasma Flame Spray Gun is a valuable new tool for the metalworking research department or production line. Operates on inexpensive inert gases with high electrical power conversion efficiency, long component life. Continuous gas streams, as high as 30,000°F., with accurate control of temperature, generated at costs of ⅛ to ½ those of oxygen-fuel gas equipment for equivalent heat output. No combustion—uses inert gases. No flashback or explosion hazards—push-button operation.

Write today for free bulletin describing the METCO Plasma Flame Gun.

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Flame Spray Equipment and Supplies
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In Great Britain METALLIZING EQUIPMENT CO., Ltd.
Chobham-near-Woking, England

Please send me free bulletin on the Metco Plasma Flame Spray Gun.

Name _____ Title _____

Company _____

Address _____

City _____ Zone _____ State _____

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FILTER ASSEMBLIES show pressure differential

The Series 2900 high-pressure fluid filter assemblies feature a pressure differential indicator with optional low-temperature lockout. The assemblies are useful for most hydraulic and pneumatic systems, aircraft and missile fuels and oxidizers, and lubricants, says **Bendix Filter Div., Bendix Aviation Corp., Dept. S/A, 434 W. 12 Mile Rd., Madison Heights, Mich.**

Differential pressure rises across the filter element as contaminant collects, and when the pressure reaches 80 psi. ±ten psi, a red-tipped pin extends to indicate the need for cleaning. On AN 6 and 12 port sizes, the lockout device prevents the indicator from functioning below a 20 to 30-deg F range. Assemblies are also available with AN Size 8 port, and envelope size of the series is similar to MS 28720 sizes. The Poromesh pleated metallic filter elements can withstand a 3500-psi differential pressure over a ±350-deg F range, and the aluminum housings are rated for a burst pressure of 12,000 psi at 100 deg F. The elements may be obtained in nominal filtration ratings from two to 40 microns.

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TRANSDUCER for low range pressure

This low range pressure transducer measures corrosive gas and liquid pressures up to 200 psi. Fast accurate responses, (1 millisecond) to dynamic pressures result from the small pressure cavity and bonded strain gage construction. Pressure on the "proving ring" sets up strains in the ring which are transmitted to the strain gages, according to **Taber Instrument Corp., Dept. S/A, N. Tonawanda, N. Y.** They can be used with the Taber indicator or standard indicators, recorders and controllers.

High overload capacity is built into this model 217 as standard. Resolution is infinite. Linearity 0.3 per cent. hysteresis 0.25 per cent, repeatability 0.1 per cent, ambient temperature —150 deg F to +250 deg F.

Write in No. 266 on Reader Service Card

PRECISION POTENTIOMETER operates at high temperatures

Model 590 alll-metal 10 turn potentiometer is capable of withstanding temperatures from —65 deg C to +200 deg C and is available in ranges from 25 to 120,000 ohms, says **Spectral Electronics Corp., Dept. S/A, 1704 So. Del Mar Ave., San Gabriel, Calif.**

Standard linearity tolerance is ±0.3 percent. Tolerances to 0.025 per cent are available on request. The unit will operate in a 95 percent RH and will function above 20g's vibration from 55 to 2000 cps. The pot can withstand 30g's shock and meet all specifications to an altitude of 30,000 ft.

Write in No. 267 on Reader Service Card

S-BAND ISOLATOR is high-power unit

Reliable operation at five mw peak and 4000 W average power is featured by the MA-154 liquid-cooled ferrite load isolator, says **Microwave Associates, Inc., Dept. S/A, Burlington, Mass.** The unit is designed for radar systems in the 2700 to 2900-mc range.

Insertion loss is less than 0.4 db and isolation is ten db minimum. The unit is rated for continuous use at 20 psig, minimum, at full rated power. A bronze RG-48/U waveguide is used by the 12 x 8 x 3½-in.-wide device. Flange connections are UG-53/U input and UG-54A/U output. Modified isolators used in tandem are available for power levels of ten kw average and over five mw peak.

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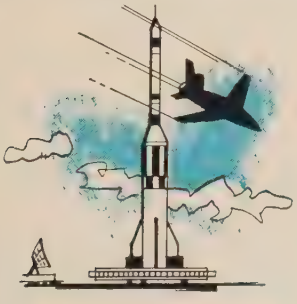
more on page 272

Intricate ducting system or individual components . . .

FLEXONICS EXPERIENCE AND ENGINEERING CAN SERVE YOU BEST



For more than half a century, Flexonics has pioneered in precision-forming thin metals into flexible carriers for a variety of media . . . and still leads. This special talent of Flexonics engineers and designers is available to you in the development of ducting systems and flexible connections.

For the most authoritative product and design recommendations covering ducting systems, flexible connectors, bellows, metal hose, and Flexon T (Teflon)—contact your Flexonics Sales Engineer or write for Flexonics Aeronautical Engineering Manual.

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In Canada: Flexonics Corporation of Canada, Limited, Brampton, Ontario

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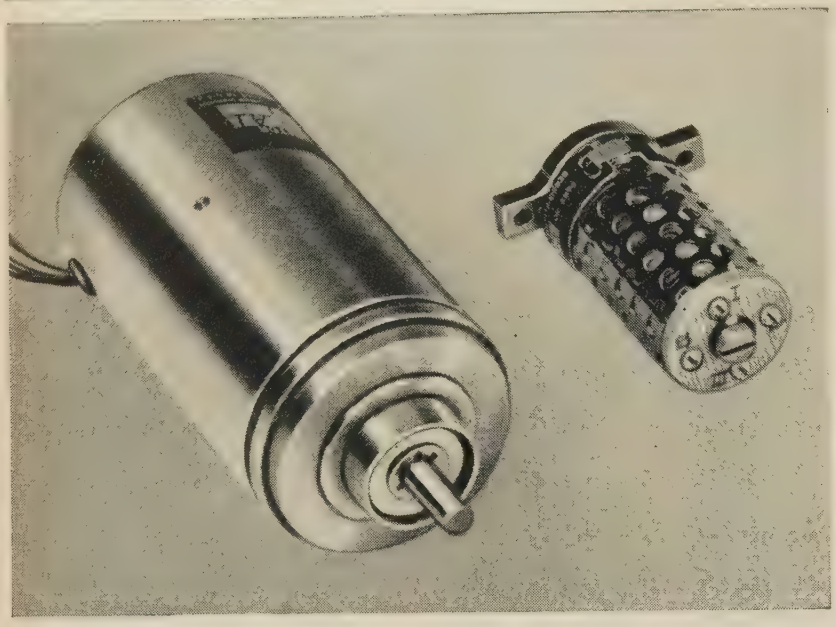
ENGINEERING
REPORT
ON BENDIX COMPONENTS



TEMPERATURE-COMPENSATED TACHOMETER GENERATORS

- SPECIFICALLY DESIGNED FOR RIGID AIRCRAFT AND MISSILE PACKAGING AND PERFORMANCE REQUIREMENTS
- ACCURACIES WITHIN 1/10 OF 1%
- TEMPERATURE RANGE FROM —55°C. TO +125°C.
- LIGHT WEIGHT—AS LOW AS 7 OZ.

Designed for use in computer circuits and velocity regulation systems, these integrating Bendix Tachometer Generators offer true laboratory quality at mass production prices. Generators are checked and calibrated by special Bendix-developed test equipment that measures speeds to an accuracy of 0.001% and voltage readings within an 0.005% accuracy.

Supplied in frame sizes 11, 15, 20, and 23—with size 10 now in development. Tailoring to customers' needs also available—for example, with unitized construction requiring no external compensation and with pulse generators for direct indication of speed measurement.

TYPICAL UNIT CHARACTERISTICS:

Excitation	115 volts
Sensitivity	1.5 volts per 1000 RPM
Phase shift	± 6 minutes
Temperature range	—55°C. to +125°C.
In-phase position error	5 min.
Linearity	0 ± .1%

For full details as related to specific applications, write—

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Teterboro, N. J.

Bendix AVIATION CORPORATION

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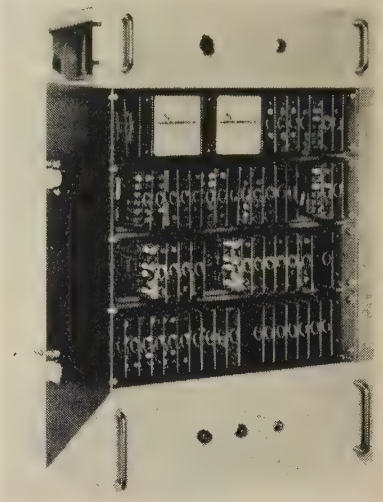
MEMORY UNIT features versatility



Versatility, reliability and economy are offered in this random access memory storage unit, says **Telemeter Magnetics, Inc., Dept. S/A, 2244 Pontius Ave., Los Angeles 64, Calif.** The unit permits use of either binary or binary coded decimal addressing, or sequential nonregenerative operation.

The Series RB memory-buffer devices are available in capacities from 128 to 1024 computer words, with four to 24 binary bits per word. Loading and unloading a word takes five usec. The flexible units are suggested for data editing and format revision, multiplexing digital data from several sources, random access storage with scanned sequential ouput, and sequential load and unload buffer, among other applications.

The units will operate reliably under ambient temperatures over a 32 to 130 deg F range.

Write in No. 269 on Reader Service Card

POWER TRANSISTORS offer "highest" ratings

The Types 2N1166 and 2N1167 transistors are two new 100-V power types that offer the "highest power ratings available," says **Semiconductor Products Div., Motorola, Inc., Dept. S/A, 5005 E. McDowell Rd., Phoenix, Ariz.** The 25-amp germanium PNP alloy junction transistors are designed for high current switching and audio applications.

A high minimum current gain of 15 at 25 amps, conservative maximum voltages, and very low saturation resistance contribute to efficiency and reliability. The 2N1166 is available in the TO-3 package with .052-in pins, and the 2N1167 has solder terminals welded to the pins. Other 25-amp BVcbo-voltage transistors range from 50 to 100 V.

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CHROMIUM *in very pure form*

The absence of any metallic or gaseous impurity in quantities greater than ten parts per million is characteristic of Iochrome chromium, says **Chromalloy Corp., Dept. S/A, 450 Tarrytown Rd., White Plains, N.Y.** Iochrome is suggested as an alloying element for gas turbine and components.

The super-pure chromium is reported to have demonstrated a greater degree of ductility than any chromium previously available. An elongation of 44 per cent and reduction in area of 78 per cent have been obtained in room-temperature tensile tests on wrought material from an arc-cast ingot. The increased ductility permits five to ten per cent more Iochrome to be added to some alloys.

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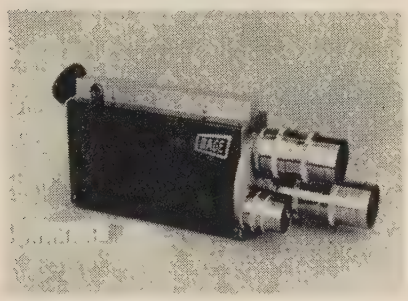
AUTOMATIC TV CAMERA *is completely transistorized*



Model 333 camera relies on transistors and printed circuits designed around separate potted, plug-in modules to achieve small size without sacrificing quality, says **Thompson Ramo Wooldridge, Inc., Dage Television Div., Dept. S/A, Michigan City, Ind.**

An outstanding feature is the automatic light adjustment, which compensates for light level changes as high as 250 to 1. The camera weighs only 4 lb and measures 2⅜ in x 5⅜ in x 7¾ in, exclusive of lens turret.

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FEED-THRU TERMINAL *made of teflon*

External connection is readily made and broken with type FT-2010 ML "press-fit" terminals. The beryllium copper clip end offers the necessary springiness to grip wire ends or other conductors securely for the duration of a test, after which the connections are pulled away, says **Sealectro Corp., Dept. S/A, 139 Hoyt St. Mamaroneck, N. Y.** The tall insulator body above or beyond the chassis or casing provides a voltage breakdown rating of 11,000 vdc at sea level.

This one-piece terminal presses into the given hole without need of screws, nuts, washers, lockwashers or other hardware.

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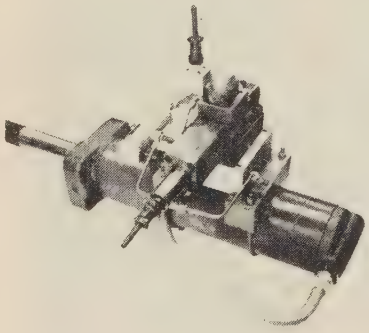
ELECTRO-HYDRAULIC *positioning systems*



This electro-hydraulic positioning system capable of speeds of 8 feet per second on a 4 in bore cylinder has an accuracy of better than one part in 2000 and is suitable for a variety of heavy duty applications in the aircraft, rocket and nuclear fields, according to **CompuDyne Corp., Dept. S/A, 450 So. Warminster Road, Hatboro, Pa.** It is available in a range of from one to 500 hp.

The system is equipped with rugged actuators that can operate at pressures up to 3000 psi. Frequency response is flat up to 19 cps in large capacity systems, and up to 50 cps in smaller systems.

Write in No. 274 on Reader Service Card

INTENSIFIER TUBE *has a 1000 brightness increase*

This light image intensifier tube WL7257 intensifies light images at levels as low as 10^{-7} foot-candles over 1000 times. The light quantum gain is approx 50 for input color temperature of 2870 deg K, says **Westinghouse Electric Corp., Dept. S/A, Box 227, Pittsburgh, Pa.**

Incoming radiation impinges on an output photo surface 5 in in diam, converting the light image to an electron image. Electron image is focused and accelerated toward an aluminum-backed phosphorus screen useful output diam of 1 in. The tube produces an image of reduced size having a brightness increase over a 1000 times minimum for input color temperature 2870 deg K and 2500 times minimium for actinic blue input.

Write in No. 275 on Reader Service Card

more on next page

ENGINEERING REPORT ON OTHER BENDIX COMPONENT PACKAGES

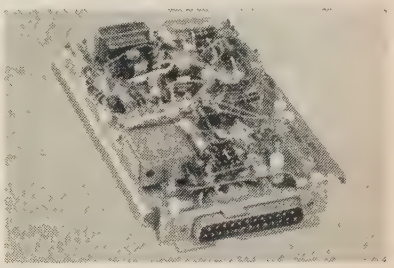
CONTROL AMPLIFIER

Electronic unit, size of cigarette package, amplifies small error signals.

This is a compact, modular electronic control amplifier that boosts small error signals to power electro-mechanical components, providing a gain factor of 500. Hermetically sealed in nitrogen and hydrogen. Latest design techniques result in direct 115-volt, 400-cps excitation with lower power consumption than on conventional bridge-type amplifiers. Meets a wide range of applications due to low power consumption, high gain, load capacity, and compactness. Ask for full details.

LOW-PASS FILTER-AMPLIFIER

Advanced circuitry provides extended operating range.



The amplifier is a keyed, plug-in, modular card assembly incorporating latest in transistor and silicon diode circuitry. It amplifies low-level 400-cps modulated signals and produces a 400-cps modulated output signal having a time lag of approximately 0.1, 3.5, 10, or 15 seconds, depending on external connections. Where memory functions are not required, eliminates need for electro-mechanical assemblies by providing either synchronization or data smoothing in the amplifier-computer. Compact design and extended operating characteristics make for flexibility of application. Write for details.

Manufacturers of
GYROS • ROTATING COMPONENTS
RADAR DEVICES • INSTRUMENTATION
PACKAGED COMPONENTS

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Bendix AVIATION CORPORATION

Teterboro, N. J.

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Edgewater

rolled steel rings

diameters 5 to 145 inches—accurate rolling reduces machining—simple or complex cross-sections—rolling gives strength, toughness

Rolled from solid blocks of steel, Edgewater Rings are strong and tough. Simple or complex cross-sections are formed to tolerances so close that only a minimum of machining is necessary. This means substantial savings in material and labor. Edgewater provides complete facilities for finishing and heat treatment, if required.

Write for descriptive illustrated bulletin.

Edgewater Steel Company

Dept. SA. P.O. Box 478, Pittsburgh 30, Pa.

Write in No. 201 on Reader Service Card at start of Product Preview Section

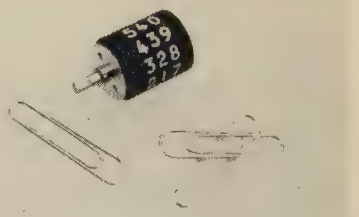
COUNTER TUBE is very sensitive

Thermal neutrons in the flux range from 8×10^{-2} to 8×10^{3} neutrons/cm²/sec can be detected by the WL-7243 proportional counter tube, says **Westinghouse Electric Corp., Dept. S/A, P.O. Box 284, Elmira, N.Y.** The device consists of three individual counters, each one in. in diameter and 10⅝ in. long.

At 2000 V, the sensitivity is about 13 counts/neutron/cm². Pulses from incident gamma photons may be biased out by suitable circuitry. The rugged tube operates in any position at ambient temperatures up to 175 deg F.

Write in No. 276 on Reader Service Card

INSTRUMENT COUNTER has no external case



This precision type counter, having all supporting structure inside the wheels, is for instrument manufacturers who require a compact, light weight counting device integrated with equipment. The case has an integral barrel on which the wheels are mounted, according to **Veeder-Root, Inc., Dept. S/A, Hartford 2, Conn.** Its numerals are available in 0.156 in or 0.188 in. height for readability, and in standard enamels or fluorescent paints.

Internal pinion construction, combined with the special precision type casting permits close tolerances and clearances.

Write in No. 277 on Reader Service Card

FAN is very small

The Aximax 1, a 1½-in diameter by 1-in long, four-oz fan, has been designed for reliable and efficient cooling of compact, airborne equipment, says **Rotron Mfg. Co., Dept. S/A, Woodstock, N.Y.** A speed of 22,500 rpm is used to deliver 23 cfm free delivery, or 19 cfm at one-in static pressure.

Clamping rims at each end of the barrel facilitate mounting and permit the fan to be turned over to reverse airflow direction. Motor designs include 115 or 200 V ac, one or three phase, 400 cps for either pressurized or non-pressurized applications, and for sine or square wave.

Write in No. 278 on Reader Service Card

more on page 276

New Money Makers for Industry:

KIN TEL CLOSED CIRCUIT TV SYSTEMS

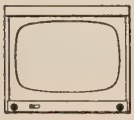
what they are, and what they can can do for you...

What is a KIN TEL Closed Circuit TV system?

The basic closed circuit television system manufactured by KIN TEL consists of a camera, a camera control unit and a monitor (receiver) each connected by cable. The camera can be located at great distances from the monitor, and any combination of cameras and monitors can be used.

The camera is small enough to hold in your hand; rugged enough to operate in 150° F. without a protective housing; sensitive enough to provide excellent pictures of objects illuminated by only a candle.

The camera control provides automatic operation. The system is continuously self-adjusting for wide variations in light levels (several thousand to one), and features automatic high definition of bright objects. The only control you have to touch is the on-off switch.

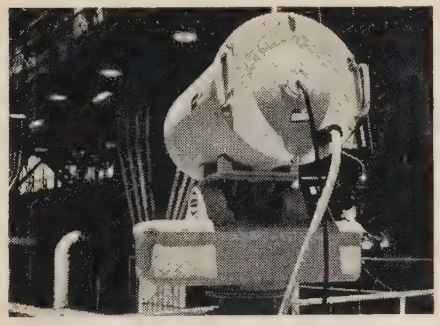


The monitor displays a crisp, clear picture...full 650-line resolution, twice that of the best home TV reception.

How are such systems used?

Today, KIN TEL closed circuit TV systems are performing a number of jobs for *hundreds* of firms, safely, inexpensively, tirelessly.

They are being used to watch operations or events that are tedious, difficult, dangerous, or even impossible for men to watch.



For example: Convair (above), Douglas, Lockheed and Northrop watch rocket tests with KIN TEL systems. U.S. Steel uses one to see inside open hearth furnaces. Westinghouse watches nuclear power reactor tests with one.

They are being used for surveillance.

For example: The San Francisco Naval Shipyard uses one to guard against pilferage.

They are being used for traffic control.

For example: The Alameda Naval Air Station uses a KIN TEL TV system to observe aircraft landings on the portion of the runway that is not visible from the control tower.

They are being used to transmit visual information quickly and accurately; for remote observation of charts, meters, graphs, schedules, blueprints, photographs, images from microscopes, fingerprints, signatures...the list is almost endless.

For example: E. F. Hutton uses a KIN TEL system to transmit stock market quotations to the offices of the firm's executives. The Los Angeles Department of Water and Power uses one for remote viewing of water-level meters. The University of California teaches physics with one.

They are being used for monitoring any operation that normally requires standby personnel.

For example: American Potash and Chemical (above) monitors conveyor line and warehousing operations with a KIN TEL TV system.

Why do these firms choose a KIN TEL system?

For a variety of reasons.

First, *reliability.* KIN TEL TV is designed for continuous duty operation in severe environments. Day in and day out, it keeps working. It's the first choice for ICBM and other missile programs that really depend on TV, that can't chance failure, that can't afford to compromise with reliability.

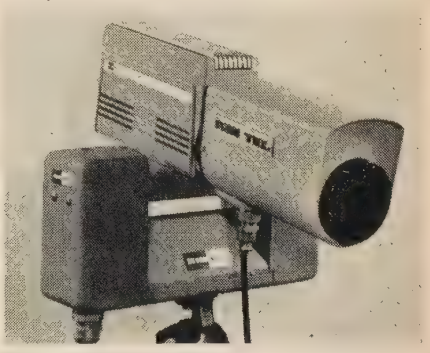
Second, *picture quality.* KIN TEL TV presents clear, sharp pictures. Full 650-line resolution provides maximum data...essential for *quantitative* observation of complex operations or transmission of printed material.

Third, *automatic operation.* KIN TEL TV is the only closed circuit system that provides entirely automatic, through-the-lens compensation for light-level changes of several thousand to one.

Fourth, the KIN TEL closed circuit TV system is extremely *sensitive.* The light required to read this page is enough for sharp clear pictures, and usable pictures can be provided with less than one-foot candle illumination.

Fifth, KIN TEL TV systems are *easy to install* and *simple to operate.* With no changes in lens iris to make, with no difficult, interacting electrical adjustments required, the only thing the operator has to know is the location of the on-off switch.

Sixth, a *complete* line of shelf-item system components and a variety of cameras and monitors make virtually any application feasible...permit observation of nearly every kind of operation, under all kinds of conditions.



For example, with system components, you can remotely position the camera, remotely select one of several lenses, remotely "zoom" in or out for closeup or wide-angle viewing, operate the camera in extremes of temperature or in explosive or dusty atmospheres, view microscope images. Whatever your viewing problem, KIN TEL probably has a *stock* solution.

Seventh, you don't have to waste your time and money on application engineering. At no obligation to you, KIN TEL's nationwide factory-trained field engineers – thoroughly experienced in optics, environmental requirements, lighting, cabling, human engineering factors, and other installation considerations–can determine whether or not closed circuit TV can be put to profitable use in your intended application.

What can a KIN TEL system do for your business?

It can do what it is doing right now for hundreds of other firms. It can save you time and money...increase efficiency...better your service to clients and customers. To find out how, write direct for catalog 6-103 and the name of your nearest KIN TEL engineering representative.

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ELECTRONICS, INC.

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KIN TEL–pioneer and leader in closed circuit television.

Write in No. 210 on Reader Service Card at start of Product Preview Section

SECURITY

Is classified security a requisite for your film processing? It's guaranteed when you specify Consolidated Film Industries...the nation's leading film processor for over 40 years.

Setting standards for the industry, CFI is still pioneering in the latest security practices. Black and white or color, your test data, training and visual aids films are under stringent security at all times.

For 16 or 35 mm, CFI developed and employs the most modern processing equipment. A broad range of special effects are available to meet every requirement.

CFI does not compromise on **quality.** Only the finest product receives our Quality Control approval.

CFI, long noted for dependable, fast delivery, serves many major aircraft and missile companies. For your convenience CFI maintains film processing facilities in New York and Hollywood. For the best in service and quality specify CFI. Call or write today for complete information!

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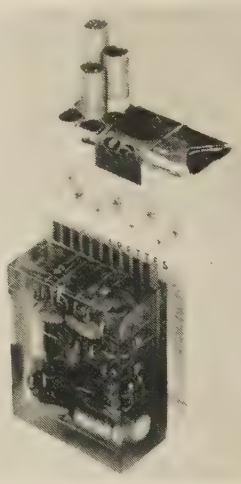
SENSOR for cryogenic liquids



A liquid level sensor that may be as far as two miles from its control-power unit accurately reveals whether a cryogenic liquid is in its liquified or gaseous state during a loading operation, says **Trimount Instrument Co., Dept. S/A, 3119 W. Lake St., Chicago 12, Ill.** Heart of the sensor is the Delta C transistor module, a one-piece, epoxy-encapsulated, 2½ x 2 x 1 in module mounted directly in the head of the probe.

Module components are protected from shock, moisture and heat by the epoxy case. Probes, which are inert to almost all reagents, are available in shielded, non-shielded and flush designs. The control-power supply, which incorporates Zener regulation, provides a sensitive micro-ammeter readout.

Write in No. 325 on Reader Service Card

SINTERED TUNGSTEN for forging

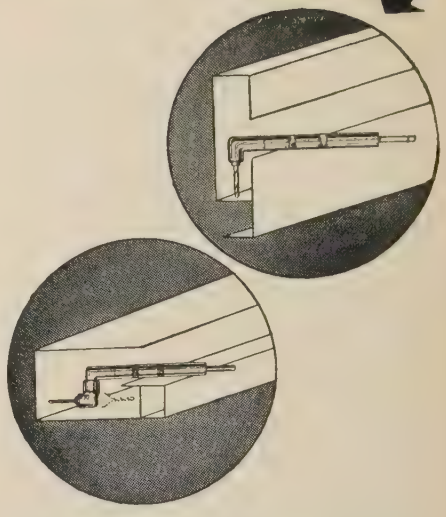
Forgeable sintered tungsten, tungsten alloy billets, and preformed shapes are now available from **Firth Sterling, Inc., Dept. S/A, 3113 Forbes St., Pittsburgh 30, Pa.** Pure tungsten and tungsten alloys, such as tungsten-molybdenum and tungsten antalum, may be obtained in hollow conical and cylindrical shapes, up to eight in. in diameter and four in. in length; billets are 4½ in. in dia and 12 in. in length, and equipment is being designed to produce ingots of pure tungsten ten in. in diameter and up to 20 in. in length.

The company is reported to be producing 99.9 per cent pure tungsten with densities exceeding 90 per cent of theoretical, which makes the material suitable for forging at 3400 to 3500 deg F. Also being produced is an alloy of half tungsten and half molybdenum with a melting point close to 5300 deg F in preformed shapes.

Write in No. 326 on Reader Service Card

more on page 278

. . . FOR THESE ANGLE DRILLING APPLICATIONS



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TERRY Angle Drilling Attachments

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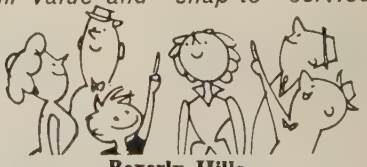
Superb accommodations, full value and "snap-to" service



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MAin 3-6688 in Seattle
or Teletype LA 1840 in Los Angeles

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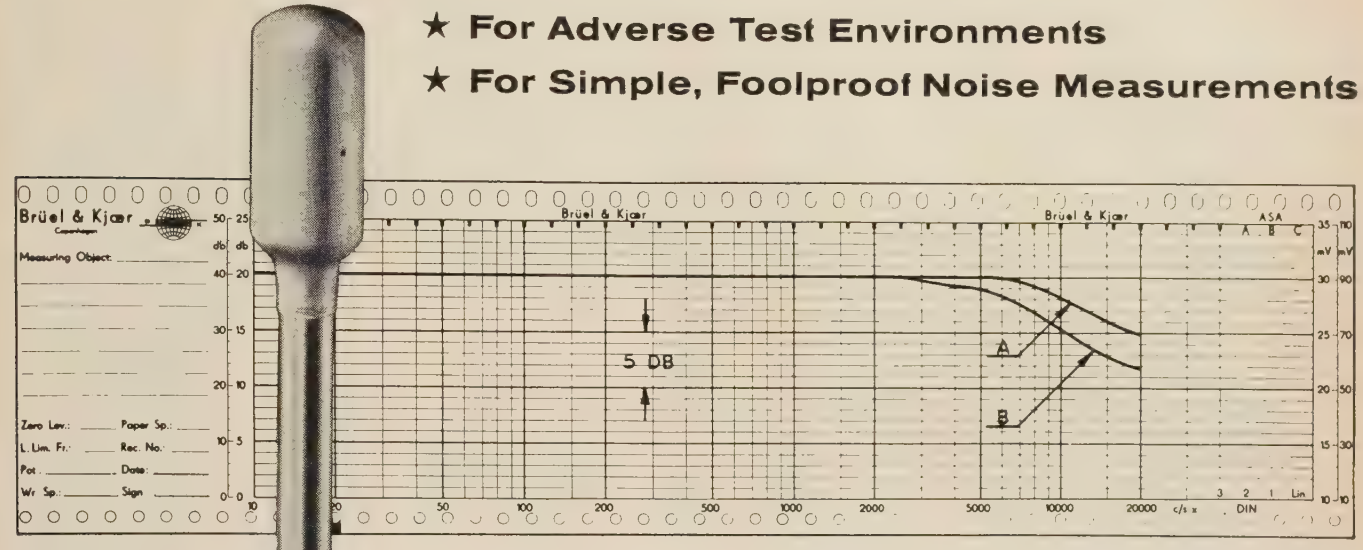
B & K Instruments Introduces:

NEW HIGH INTENSITY MICROPHONE

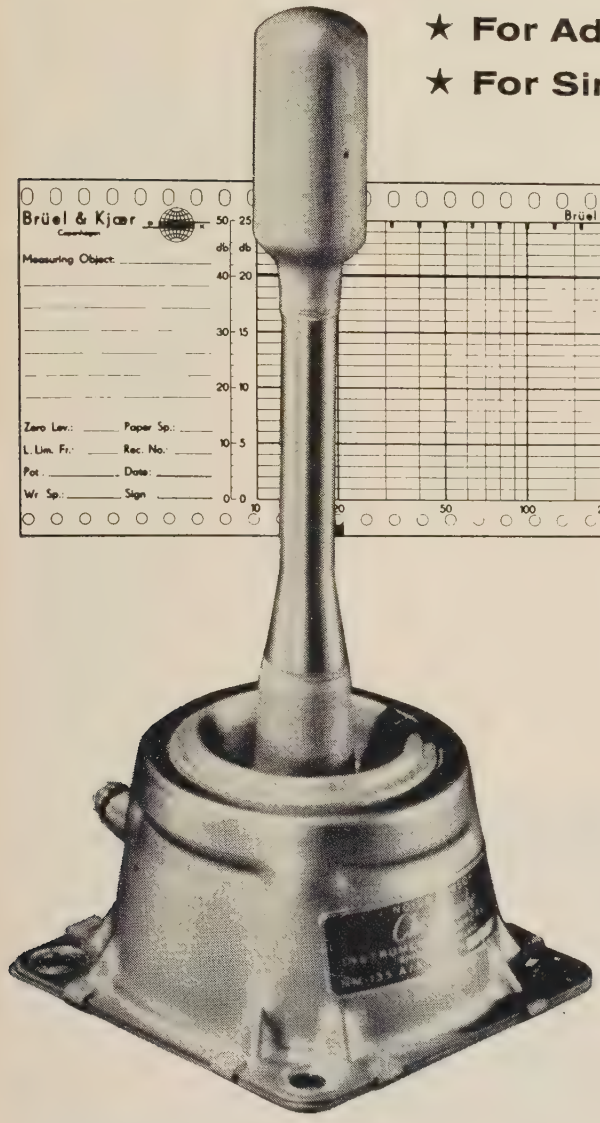
★ For Adverse Test Environments

★ For Simple, Foolproof Noise Measurements



A. Typical Free Field Response for Model NM 125

B. Typical Free Field Response for Model NM 135



measure "in flight" and test stand acoustic environments as simply as acceleration

Model NM 125 — 4 inches high
Model NM 135 — 5¾ inches high

★ Self-Generating Sensor

★ Low Sensitivity to Shock & Vibration

★ Temperature Range −75° to +500° F.

★ Dynamic Range 90 to 200 db.

★ Unaffected by Weather

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New...from MARSH!

Small solenoid valves that fill a BIG order

Conduit-type Master-mite. Grommet-type also available.

Designed to meet the need for positive-acting tight-seating valves for use on wide variety of media, including oxygen, hydrogen, acetylene, etc.

Two Types:
Conduit type and grommet type. Port sizes 1/8" and 1/4" NPT.

Ten orifice sizes:
3/64" through 1/4".

Wide range of voltages:
Standard with 115 V. A. C. but also available in 12, 24, 208, 230, 460 V. A.C.

Pressure to 540 psi.

Small, but with more strength in the Marsh manner. Coils never overheat. Entire assembly leak tight. Remarkably quiet operation. Cleanable without breaking connections. Used in any position. Bodies either brass bar stock or 18-8 stainless steel. All moving parts stainless. Underwriters' approved for use on oxygen and hydrogen and as safety valves.

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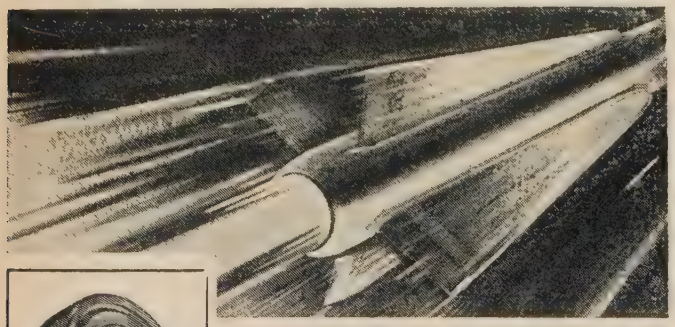
Dept. 13, Skokie, Illinois
Division of Colorado Oil and Gas Corporation
Marsh Instrument & Valve Co., (Canada) Ltd., 8407 103rd St., Edmonton, Alberta, Canada, Houston Branch Plant, 1121 Rothwell St., Sect. 15, Houston, Texas.

Write in No. 234 on Reader Service Card



Minute Giants . . .

B.M.B. Miniature Bearings to the highest precision limits, are made specially for Space craft, missile or ground support instrumentation.

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Manufacturing Associates, 1416 Westwood Blvd., Los Angeles 24, California, U. S. A.

BRITISH MANUFACTURED BEARINGS CO., LTD.

Sole Selling Agents:

B.M.B. Sales Ltd., High Street, Crawley, Sussex, England.

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DIAL METER measures grooves

This Quicktest line of precision dial measuring instruments is designed to determine internal groove diameter in difficult-to-measure situations, says **Testing Machines, Inc., Dept. S/A, 72 Jericho Turnpike, Mineola, N. Y.** The distance between extremities of the contacting feelers is recorded directly on a graduated dial.

Contactor points are slim, needle-shaped points that are adjustable or replaceable, and angular points are available. The angular points measure internal groove diameters immediately in front of the shoulder or at the bottom of a blind hole. The Quicktest instruments will measure diameters of internal grooves from .4 to four in.

Write in No. 327 on Reader Service Card

RUGGED HONEYCOMB is low cost

Welded stainless steel honeycomb for air and space craft that exhibits extraordinary resistance to handling damage and possesses greatly improved physical properties is lower in cost than Condition A core materials, according to **Hexcel Products, Inc., Dept. S/A, 2332 Fourth St., Berkeley 10, Calif.** Condition C honeycomb's resiliency is the basis of its damage resistance, and it also possesses a metallurgically superior weld and improved metallurgical structure, which aid in avoiding subsequent brazing problems.

Cell sizes of the high temperature material are 3/16 and 1/4 in. in gauges of .001, .0015, and .002. Alloys available include: PH15-7MO; 17-7PH; and AM 350.

Write in No. 328 on Reader Service Card

more on page 280

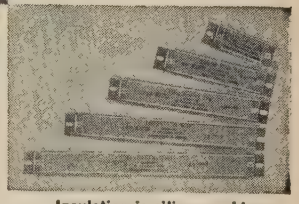
New
POWER RESISTORS for FLIGHT USE

ELECTRO-FLEX

specialists in HEATING ELEMENTS

LESS SPACE—LESS WEIGHT

New lightweight, space-saving resistors permit substantial efficiencies and economies in aircraft and missile electronic apparatus. Units are mounted in direct contact with inner surface of chassis or case so that 25% to 40% of heat generated is emitted to atmosphere. Derating curves are available.



Available in the following ratings and sizes

Power Rating	Envelope Dimensions	Approx. Weight
40 Watts	7/32 x 1 5/16 x 4	.027 lbs. ea.
80 Watts	7/32 x 1 5/16 x 6	.040 lbs. ea.
120 Watts	7/32 x 1 5/16 x 8	.053 lbs. ea.
160 Watts	7/32 x 1 5/16 x 10	.067 lbs. ea.
200 Watts	7/32 x 1 5/16 x 12	.080 lbs. ea.

Insulation is silicone rubber—operable continuously at 450° F.
Mounting metal—Alclad aluminum.
Connection tabs—silver plated brass.

Special washers permit bolt or rivet mounting. Adhesive supplied provides good thermal transfer from resistor to mounting wall.

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Handy, 12-page, fully illustrated booklet describes in detail all basic specifications, properties, uses and performance characteristics for "Fairprene"* coated fabrics and cements.

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Please send me free copy of Du Pont's guide to coated fabrics for industry.

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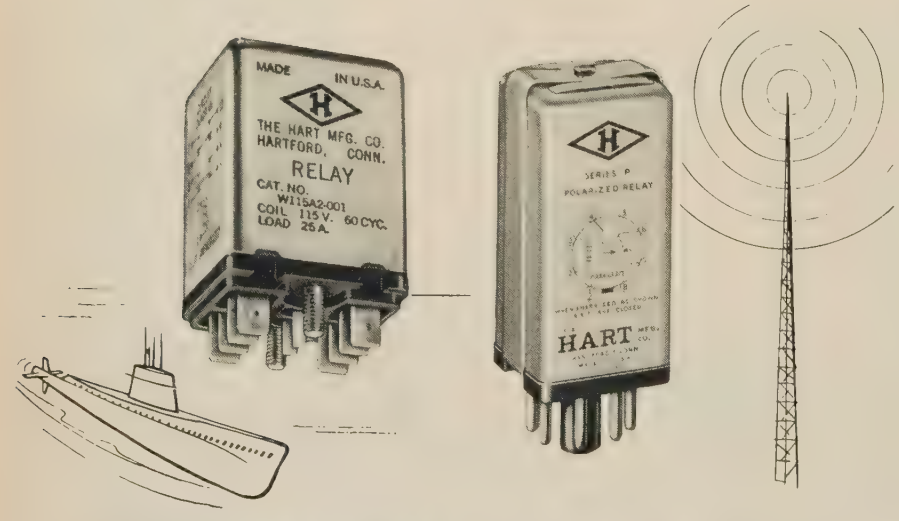
Heart of the Control System



"DIAMOND H" Relays

Look into the heart of the control system for a missile, a computer, a nuclear submarine, or a great many other critical applications. You might be surprised how often you'll find "Diamond H" relays.

Unless, of course, you're one of the increasing number of engineers who've already selected "Diamond H" relays for a spot where they just have to work despite all sorts of adverse conditions.

Hart makes relays of three basic types: miniature, hermetically sealed, aircraft-missile relays (Series R/S); high speed, sensitive, polarized relays (Series P), and general purpose AC, DC relays (Series W).

Technical literature outlining the wide range of characteristics available with each type relay is yours for the asking. You'll find "Diamond H" engineers uncommonly adept at working out a variation of the basic designs to meet your set of specific requirements.

Tell us your needs . . . by phone, wire or letter.

THE HART MANUFACTURING COMPANY

212 Bartholomew Ave., Hartford 1, Conn.

Write in No. 209 on Reader Service Card at start of Product Preview Section

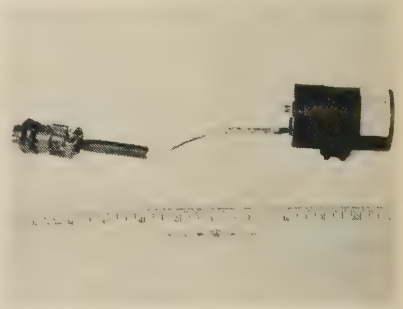
PRECISION GEARS are stainless steel

These solid hub type precision gears are available in stainless steel and anodized aluminum in standard diametral pitches 48 through 200 with consecutive tooth selection range from 20 through 120 teeth, says **U. S. Gear Corp., Dept. S/A, 81 Bay State Road, Wakefield, Mass.**

These precision gears are manufactured to AGMA precision 1 and 2 tolerances and are available in .120, ⅛, 3/16 and ¼ in bore sizes.

Write in No. 329 on Reader Service Card

TRANSDUCER operates to 3000 psi



A new pressure transducer, SMI type TR 719, converts an ac excitation to a dc output signal that is proportional to differential or absolute pressure. The unit has been designed for use in telemetering pressures such as aerodynamic, power plant or hydraulic systems. It is ideally suited for high accuracy and high environmental missile requirements where common potentiometer transducers exhibit excessive friction, resolution and unreliability, says **Servomechanisms, Inc., Dept. S/A, Subsystems Div., 12500 Aviation Blvd., Hawthorne, Calif.**

The unit operates in the ranges from 15 to 3,000 psi and its rugged design allows accurate and reliable operation under relatively high shock, vibration and accelerations.

Write in No. 330 on Reader Service Card

RF CONNECTORS are extremely small

This RF cable connector is slightly larger than RF-/U cable diameter and is only a fraction of an inch in length. It uses insulators machined to .001 in tolerances, according to **Tri-Point Plastics, Inc., Dept. S/A, 175 I. U. Willets Rd., Albertson, L. I., N. Y.** Barely ⅛ in diameter and ½ in long, the gold-plate units contain TFE insulators only .120 in diam, .420 in long, with wall thicknesses of .016 in.

Despite the size, the connectors are said to retain "full-size" RF connector characteristics.

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more on page 282

BUT . . .

Heating Blankets and other Woven Heating Elements by SAFEWAY can make your COLD problems OLD problems!

Be it the frigid altitudes at which manned aircraft fly, the cold, trackless space domain of missile and satellite, or the icy arctic wastes of DEW Line installations — it's always "winter" somewhere.

Environmental temperature problems common to this kind of "winter" beset fuels and lubricants and hamper the operation of many types of sensitive equipment.

But SAFEWAY dispels such problems by packaging *controlled heat* for application *everywhere*. Among the wide variety of heating blankets and woven-wire heating elements which have been engineered by SAFEWAY to meet exacting specifications are:

- **heating elements for launching equipment and for airborne gyros, cameras, computers, servos and batteries — for missiles or aircraft**
- **de-icing units for airfoil surfaces**
- **heating elements for all types of ground support equipment**
- **defrosting units for industrial and commercial refrigeration**
- **heating blankets for honeycomb and metal-to-metal bonding**

For your copy of a fact-filled folder, please write:

If it has to be heated (and the "it" can be just about anything), you can rely on SAFEWAY engineers to study your problems carefully, and — without any obligation — submit an appropriate recommendation.

Safeway HEAT ELEMENTS INC.

680 Newfield Street • Middletown, Connecticut

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GROW WITH AIRESEARCH IN ELECTRONICS

AiResearch expansion in electronics and electromechanical activity is creating outstanding positions at all levels for qualified engineers.

ELECTROMAGNETIC DEVELOPMENT

Work with magnetic amplifiers requires knowledge of electromagnetic theory, materials and design methods.

Openings also exist in the following areas: Flight Systems Research ... Controls Analysis ... Data Systems Research ... Flight Data Components ... Airborne Instrumentation Analysis and Design ... Instrument Design.

Send resume to: Mr. Robert Richardson

THE GARRETT CORPORATION

AiResearch Manufacturing Division

9851 So. Sepulveda Blvd., Los Angeles 45, Calif.

Check Employment Inquiry Form on Page 195

TEST SET checks transistors

Rapid transistor evaluation through direct readout of the hybrid parameter Beta, input impedance and collector cut-off current has been made possible by the Model 545-B portable transistor test set, according to **Metronix, Inc., Dept. S/A, Chesterland, O.** Germanium or silicon transistors may be checked for defects, tolerances, changes or deterioration.

The Model 545-B, designed for production lines and laboratories, uses an internal battery or external dc for the test voltage. An internal oscillator supplies the one-kc test frequency, but use of an external oscillator and any frequency between 200 cps and 50 kc is permissible. Beta ranges are zero to 30/100/300. Input impedance may be measured from 500 to 20,000 ohms and collector cut-off current from zero to 50 ua.

Write in No. 332 on Reader Service Card

COMPUTER TRANSISTORS are alloy types

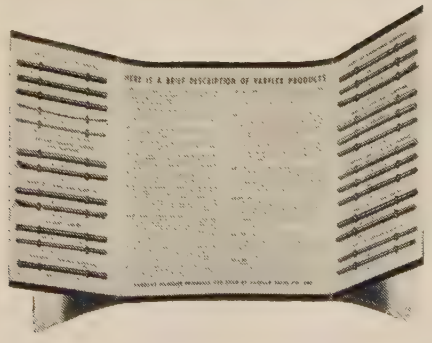
Eight types of alloy germanium computer transistors, consisting of four PNP and NPN pairs, are now generally available. A 1½-year volume production for a single consumer has resulted in the perfection of quality assurance controls and techniques, and in lower costs, says **Texas Instruments, Inc., Dept. S/A, P.O. Box 312, Dallas, Texas.**

The collector-to-base voltage for the PNP Series 2N1303, -1305, -1307 and -1309 is 30 V and for the NPN types 2N1302, -1304, -1306 and -1309, it is 25 V. Collector and emitter currents are both 300 ma. Emitter-to-base voltages are 25 V, and collector-to-emitter voltages range from 15 to 25 V.

Write in No. 333 on Reader Service Card

more on page 284

Send for this *Free* SAMPLE FOLDER...



Contains 25 different test samples of high-dielectric Insulating Tubing & Sleeving.

Includes samples and descriptions of: Varglas Silicone • Varfil Sleeving and Tubing, polyester resin impregnated Fiberglas • Varglas Tubing and Sleeving • Varglas Non-Fray Sleeving • Varflo Tubing and Sleeving • Varflex Cotton Tubing and Sleeving • Syntholvar Extruded Tubing

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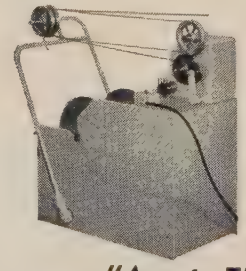
ARTOS MODEL CS-6

. . . any operator can produce 3,000 or more leads per hour in any insulated wire to 10-ga.

END wire stripping bottlenecks! You can measure, cut off and strip insulated wire with this *fully automatic* ARTOS machine . . . over 6,000 leads per hour with some types of wire.

With unskilled labor, solid or stranded wire leads are produced in lengths from 2" to 194"—and stripped up to 2" at one or both ends.



(Left) AE-563 PREFEEDER

Completely automatic, self-adjusting unit with ⅓ hp. motor. Requires no attention after wire has been threaded into stripping machine. Heavy reels roll into cradle or can be mounted on a shaft.

ALSO AVAILABLE: Extra equipment to mark leads with any code. Other machines also attach prefabricated terminals in strip form to your wire leads.

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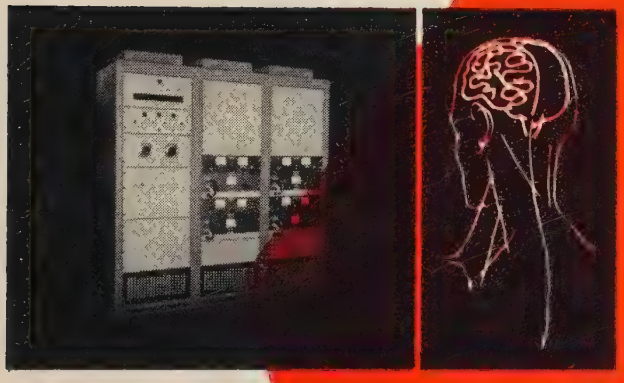
TO BETTER THE REAL THING



ERCO creates experience

A missile once launched is committed. The system required to accomplish this launching must be maintained at a level of peak effectiveness at all times.

Malfunction in time of need could spell disaster. Predetermination of possible malfunctions and the training of personnel to detect, analyse, and correct rapidly is essential to preventing systems failures.

Under contract to General Electric, ERCO has developed and built equipment to provide familiarization and proficiency training for Air Force crews who operate the Atlas ICBM guidance systems. This equipment has been designed to provide personnel with:

Basic Training in guidance system equipment... Overall familiarity with the system for each of the crew members... Recognition, analysis and correction of the system's malfunctions.

The ability of our modern weapons to fulfill their defensive missions rests largely on the men who operate and maintain these systems.

Training equipment systems, such as the one described, are designed to permit the man to live and re-live an experience hundreds of times before it happens.

For a professional study of your current project, we suggest you contact Manager-Marketing:

ERCO

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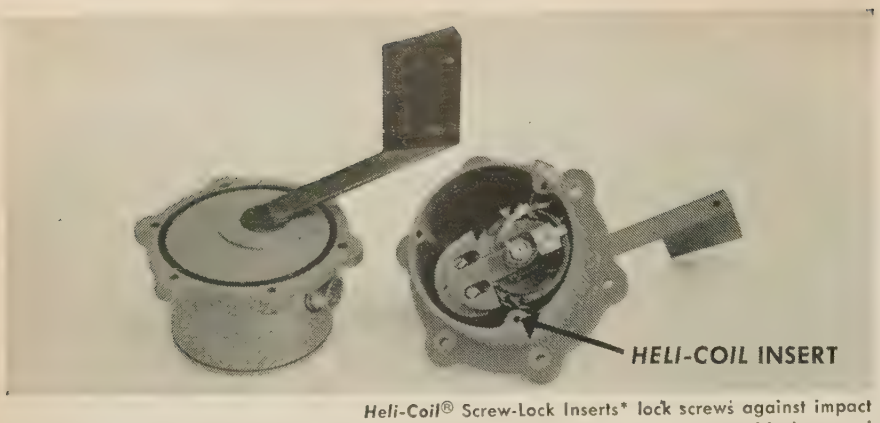
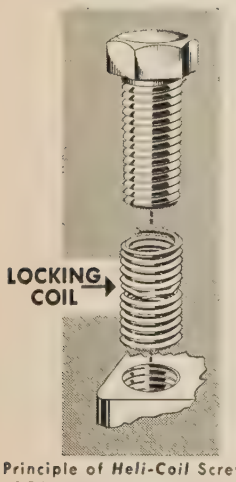


Heli-Coil® Screw-Lock Inserts* lock screws against impact and vibration and permanently protect critical tapped holes in this transducer assembly.

Critical Electronic Controls Get Internal-Locking, Protective Threads with HELI-COIL Screw-Lock Inserts



Principle of *Heli-Coil* Screw-LOCK Insert. Locking center coil grips internally, holds screw firmly.

Electronic control devices for aircraft and missiles, like this angle of attack vane transducer made by U. S. SCIENCE CORPORATION, LOS ANGELES, CALIF., have to withstand severe vibration, impact, corrosion and temperature change. They must be made of light materials and still have strong threads — able to hold fasteners tightly and stand frequent assembly and disassembly.

U. S. SCIENCE insures rock-solid screw assemblies by protecting vital tapped holes with one-piece *internal-locking* **Heli-Coil** Screw-LOCK Inserts. These precision formed, stainless steel wire inserts eliminate thread wear, lock screws securely — without resort to clumsy, external lock nuts and lock wiring.

Simple Installation Procedure

U. S. SCIENCE finds it easy to install *Heli-Coil* Screw-LOCK Inserts. Drilled holes are tapped with a *Heli-Coil* tap and the Inserts wound in with a prewinder inserting tool. Conventional screws are used in assembling the unit.

Heli-Coil Screw-LOCK Inserts

- positively lock fasteners against loosening under impact and vibration
- prevent thread wear, stripping, corrosion, galling and seizing
- eliminate lock nuts, lock wiring, other supplementary locking devices
- permit repeated disassembly and reassembly
- can be used in standard proportion bosses without need for redesign
- save assembly time, space, weight and cost
- meet government specs for locking torque and vibration

*Patented

HELI-COIL CORPORATION
DANBURY, CONNECTICUT

HELI-COIL CORPORATION, 112 Shelter Rock Lane, Danbury, Connecticut
Send complete design data on *Heli-Coil* Screw-LOCK Inserts

NAME_____TITLE_____
FIRM_____
ADDRESS_____
CITY_____ZONE____STATE_____

Write in No. 214 on Reader Service Card at start of Product Preview Section

ANGLE INDICATOR is very accurate

The small, versatile, precise angle indicators in this line are complete servo systems that offer a numerical presentation of angular positions, says **Kearfott Co., Inc., Dept. S/A, 1500 Main Ave., Clifton, N.J.** Each unit includes indicator, motor, and servo amplifier.

Characteristics include a repeatability of within 0.6 min, either clockwise or counterclockwise, for any angular position, and a readability of 0.5 min from zero to 360 deg. Accuracy is plus or minus six min, and sensitivity, 0.5 min maximum. Size of the laboratory, field or production-work device is 1¾ x 9½ x 8½ in.

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RF COAXIAL CABLE for high temperature service

This low-loss, high-temperature RF-coaxial cable meets requirements of high temperature coaxial cable design objectives within the frequency range of 10 to 1500 mc, says **Thomas A. Edison Industries, Dept. S/A, West Orange, N.J.**

The basic characteristics of the unique insulating material, a specially processed silica, enable the cable to show excellent attenuation frequency properties at room temperature with only minor changes at temperatures to 500 deg C.

Write in No. 335 on Reader Service Card

DETENT PIN for miniature assemblies

Faspin is a quick release pin that may be quickly and easily assembled or disassembled for use in miniature or subminiature assemblies and mechanical units. The miniature device is specifically designed to meet requirements of the aircraft and missile industry, says **Aerofast, Dept. S/A, P. O. Box 324, Wheaton, Ill.**

The steel used for the $\frac{3}{16}$-in dia pin contributes high shear strength and surface hardness. Faspin is available in all grip lengths.

Write in No. 336 on Reader Service Card

more on page 286

Will tomorrow be a challenge ...or a bore?

If you feel that your present job is not fully tapping your potential, here are 4 new career opportunities for Electronics Engineers that have every bit of the challenge you may be looking for . . .

1 *Site Systems Reliability Engineer:* This position calls for a seasoned engineer capable of integrating and directing on-site reliability assurance activities necessary to secure customer acceptance of the detection system. Unusual combination of technical ability, relations and communications (written and spoken) is required. Desirable experience includes approximately ten years in design and field installation of transmitters on electronic systems with ability in both electronic and mechanical fields. Ability to motivate technicians for optimum performance is necessary. Salary structure is equal to the challenge.

2 *Radar Equipment Systems Specialist:* This position calls for a creative engineer capable of conceiving and directing the design of long-range radar systems. Desirable experience includes around ten years in at least one of the following: radar systems design, antenna systems, R.F. components, radar receiver systems or radar data processing systems. Salary structure is equal to the challenge.

3 *Advanced Systems Engineer:* This position calls for a creative engineer capable of defining future defense and space detection problems as well as the ability to conceive and establish the feasibility of optimum systems solutions to these problems—making use of the most advanced techniques and understanding. He must recognize the need for and coordinate the development of new techniques and the exploration of new phenomena in the area of detection systems. Background desired: Bachelor degree plus a combination of advanced training and several years experience in both the theoretical and practical aspects of detection systems engineering. A desire to work in the conceptual phase of system design with the analytical ability required to evaluate and demonstrate the effectiveness of proposed systems.

4 *Advanced Radar Systems Analysis and Development Engineer:* Engineers are needed who are able to visualize and define future defense and space problems—conceive advanced radar systems to solve them. An advanced degree and/or strong background in system analysis and design is essential. Assignments open include: analyze and define requirements for advance detection systems and determine broader parameters for such systems, establish their feasibility; analyze long range missile detection systems and specify optimum configuration on the basis of utility, performance, cost and delivery. 228-9

All of these openings are on General Electric missile and satellite detection projects and will be filled with engineers having the capability and desire to make creative contributions.

Write in confidence to T. M. George, Supervisor—Personnel Administration

Missile Detection Systems Section
HEAVY MILITARY ELECTRONICS DEPARTMENT

GENERAL ELECTRIC

SYRACUSE, NEW YORK

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ONE BEST ANSWER
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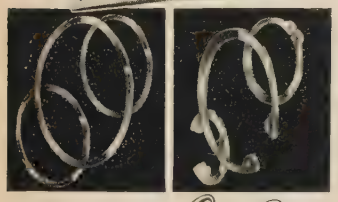

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another product of **Thompson Ramo Wooldridge Inc.** automotive group
548

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FUSE
is temperature-sensitive

A miniature fuse designed to fire at predetermined ambient temperatures has been offered as a protective thermal device for critical circuits demanding high reliability and fast, positive action, says **Networks Electronic Corp., Dept. S/A, 14806 Oxnard St., Van Nuys, Calif.** The Model 7503 fuse, which is hermetically sealed, meets environmental requirements for aircraft, missile and ordnance applications.

The device will handle up to 15 amps continuous current over a —65 to +200 deg-F range, and the circuit opens when a nominal temperature of 281 deg is reached. Internal resistance is under one milliohm at 15 amps. Variations in firing temperatures and current carrying capacities are available.

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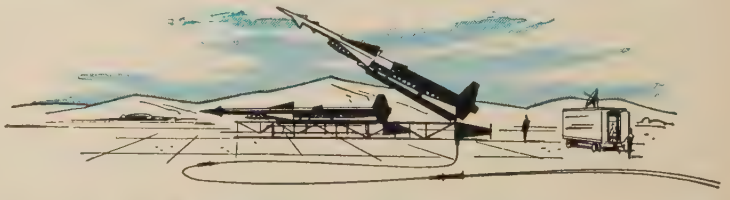
TRANSDUCERS
are highly sensitive

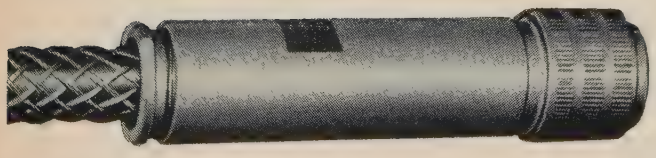
This converter-transducer provides direct current output with alternating current input and replaces a potentiometer where ac is available. Advantages are said to be no sliding contacts, infinite resolution, resistance to severe shock and vibration, higher linearity, and sensitivity up to 500 v per inch displacement, according to **Vinson Mfg. Co., Dept. S/A, 8044 Woodley Ave., Van Nuys, Calif.** Threshold sensitivity is better than .0001 per cent of full scale.

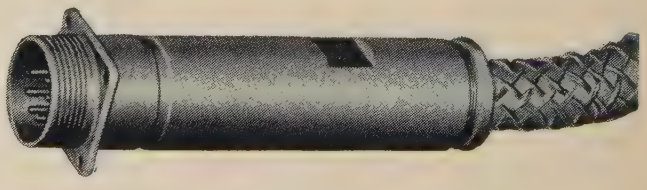
Temperature range is —320 deg F to +250 F. It is stainless steel and is used in the liquid oxygen regulator on a missile engine.

Write in No. 338 on Reader Service Card

more on page 290







Why it pays you to specify

Bendix QWL Electrical Connectors for use with Multi-conductor Cable

For use with multi-conductor cable on missile launching, ground radar, and other equipment, the Bendix* QWL Electrical Connector meets the highest standards of design and performance.

A heavy-duty waterproof power and control connector, the QWL Series provides outstanding features: • The strength of machined bar stock aluminum with shock resistance and pressurization of resilient inserts. • The fast mating and disconnecting of a modified double stub thread. • The resistance to loosening under vibration provided by special tapered cross-section thread design. (Easily hand cleaned when contaminated with mud or sand.) • The outstanding resistance to corrosion and abrasion of an aluminum surface with the case hardening effect of Alumilite 225 anodic finish. • The firm anchoring of cable and effective waterproofing provided by the cable-compressing gland used within the cable accessory. • The watertight connector assembly assured by neoprene sealing gaskets. • The additional cable locking produced by a cable accessory designed to accommodate a Kellems stainless steel wire strain relief grip. • Prevention of inadvertent loosening insured by a left-hand accessory thread. • The high current capacity and low voltage drop of high-grade copper alloy contacts. Contact sizes 16 and 12 are closed entry design.

These are a few of the reasons it will pay you to specify the Bendix QWL electrical connector for the job that requires exceptional performance over long periods of time. *TRADEMARK

Export Sales and Service: Bendix International Division, 205 E. 42nd St., New York 17, N. Y. Canadian Affiliate: Aviation Electric Ltd., 200 Laurentien Blvd., Montreal 9, Quebec. Factory Branch Offices: Burbank, Calif.; Orlando, Florida; Chicago, Ill.; Teaneck, New Jersey; Dallas, Texas; Seattle, Washington; Washington, D. C.

Scintilla Division
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Bendix
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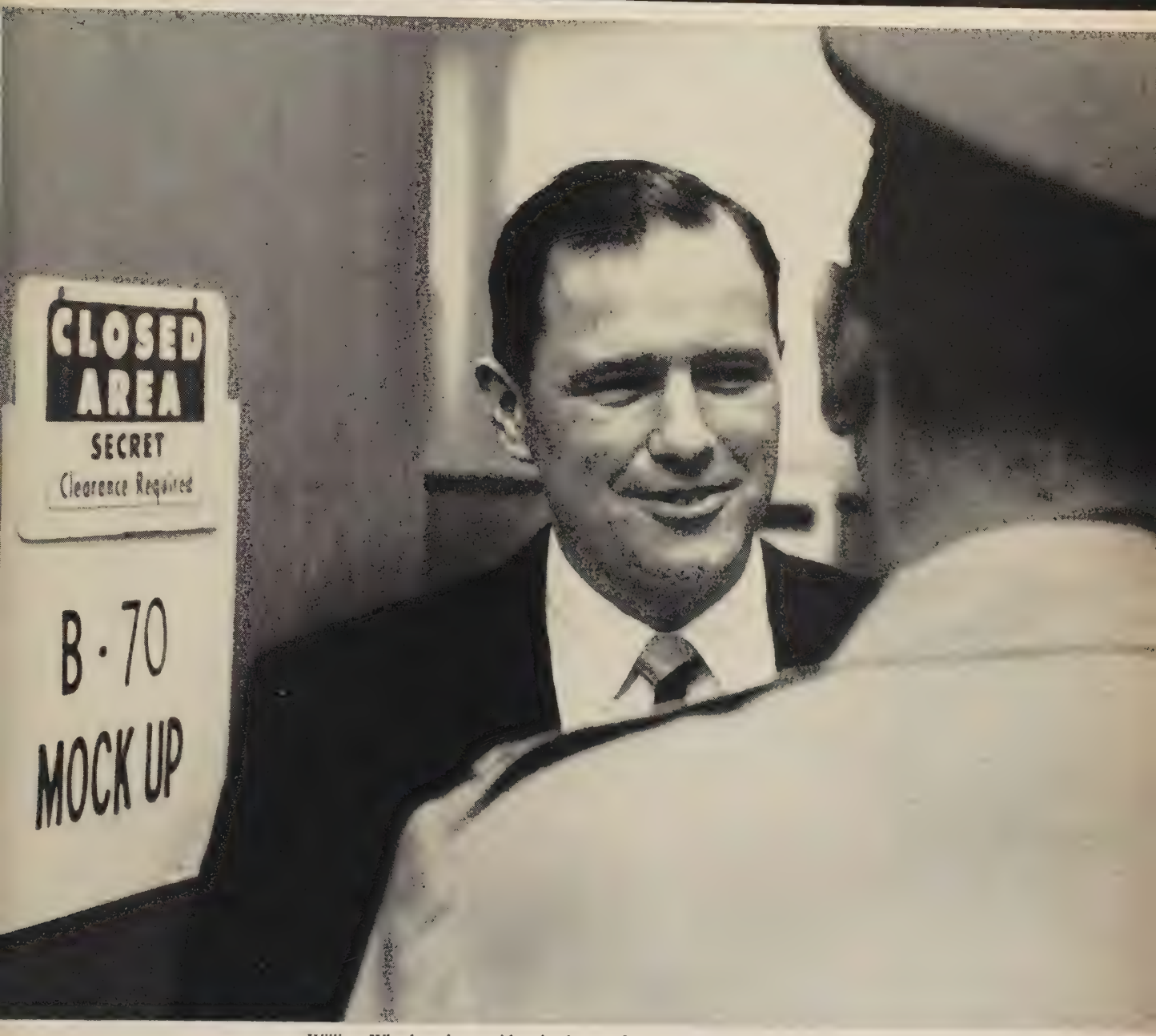
SEASONED IN THE SERVICE

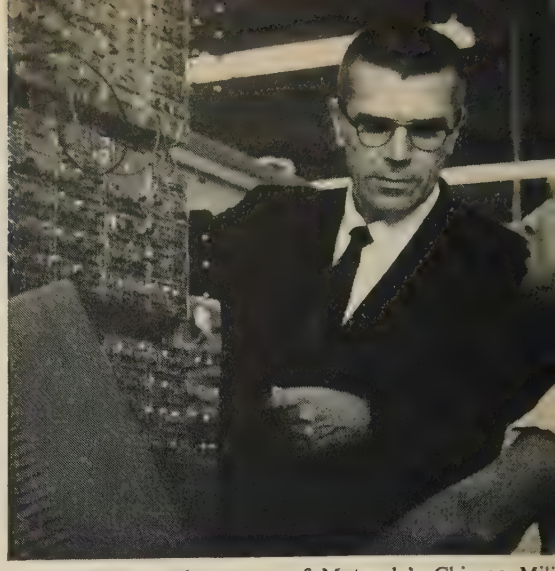


William Wheeler, vice president in charge of Motorola's Military Electronics Division discusses participation role in the B-70 project being developed for the Strategic Air Command at North American.

"North American's pre-award analysis and evaluation, before awarding the contract for the Mission and Traffic Control System of the B-70 Valkyrie to Motorola, was one of the most thorough and extensive ever made."— North American Aviation, Inc.

On the next two pages: Motorola's Seasoned Military Service Record.

Since before World War II, Motorola has demonstrated its exceptional ability in military electronics on assignments that include communications equipment... radar... missile guidance... data processing and display... antisubmarine warfare... demonstrating with each success the value of a technical task force that is...



Roy Olson, general manager of Motorola's Chicago Mili Electronics Center, which emphasizes work in surface and surface electronic equipments and systems.

Seasoned in the service

Hundreds of thousands of Motorola walkie-talkies were produced for World War II combat use.

Few weapon systems now under development are expected to play as important a role in U.S. defense in the coming decade as the B-70 Valkyrie. This fantastic new weapon will cruise at more than 2000 m.p.h. at altitudes over 70,000 feet.

Motorola's long record of military electronic achievements led to its appointment as major systems manager to develop and build the B-70's vital Mission and Traffic Control System.

This major system encompasses the communications, navigation, identification (IFF), and landing aids. It will keep B-70 crews in constant contact with each other and with U.S. headquarters from anywhere on the globe. It will provide the Valkyrie with its capability to be electronically directed to a designated target anywhere in the world and be immediately recalled on command.

High-level responsibilities such as this are not new to Motorola. It was in June of 1940 that the prototypes of the history-making Motorola walkie-talkie were delivered to the U.S. Army Signal Corps. During World War II, Motorola not only supplied vast quantities of equipment that kept advancing U.S. ground troops in constant communications, but was also chosen by the Signal Corps to direct and manage the supply of the entire U.S. Army's need for electronic crystals. These critical frequency-determining components were vital to radio communications

In the late forties and early fifties it was weapon fuses, radar bombsights and tactical microwave communications. Today, in company owned research and production centers across the country, thousands of Motorola engineers and scientists are at work on a broad range of military projects. Included are missile guidance high-resolution radar, sonobuoys, the next generation of equipment for radio-telephone communications between ground troops, and advancement of the frontier of knowledge in solid-state electronics.

Motorola's exclusive concentration in elec tronics, its cost-conscious approach to produci bility, and its preoccupation with reliability are evident in every military product from the small est solid-state device to the most complex weapon systems. Small wonder that with the mil tary, Motorola rates one of the highest confi dence quotients among suppliers of electronics equipment. For in the development and produc tion of military electronics, it has been proved time after time, *there is no substitute for sea soned experience.*

For a comprehensive brochure on Motorola's Military Electronics capabilities, write Techn cal Data Service, Motorola, Inc., Military Elec tronics Division, 8201 East McDowell Road Scottsdale, Arizona.

MOTOROLA

Military Electronics Division / CHICAGO • PHOENIX • RIVERSIDE

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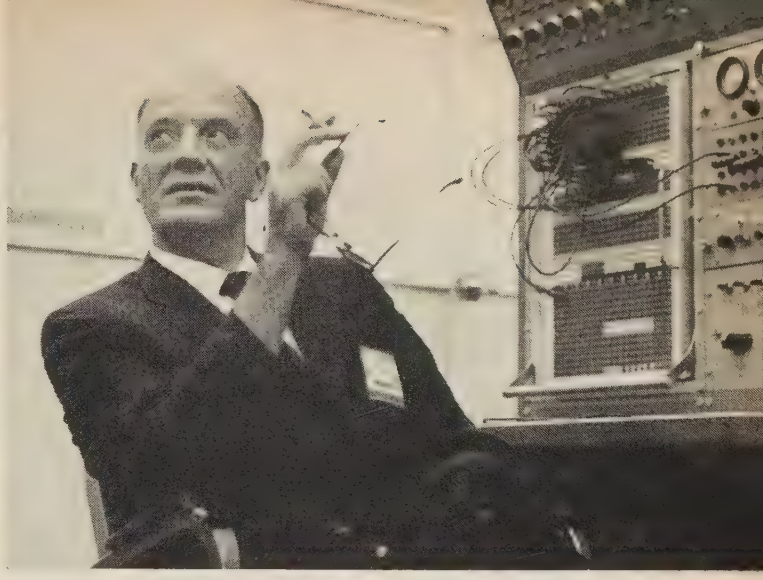
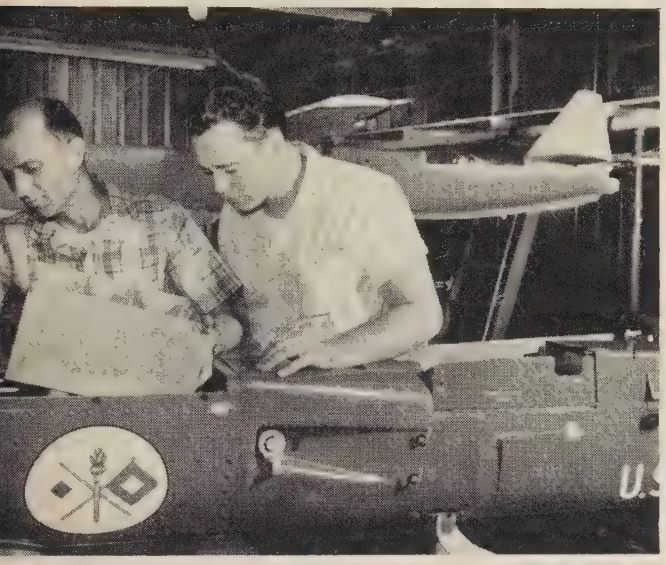
8330 Indiana Avenue, Riverside, California

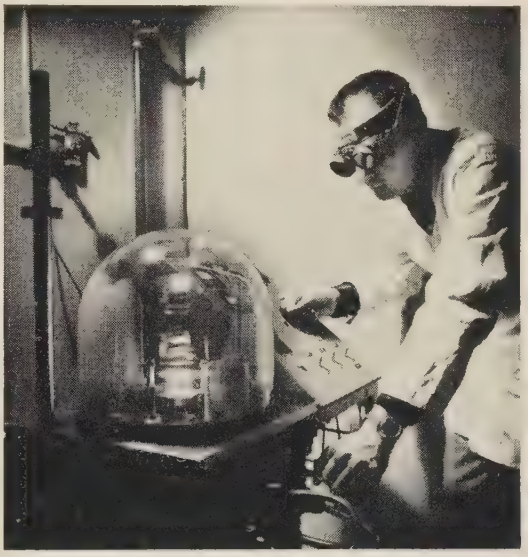
e Chambers, Motorola vice president and general manager of the Western ilitary Electronics Center, directs Phoenix laboratories concerned prima- y with work on sophisticated airborne and spaceborne electronics.



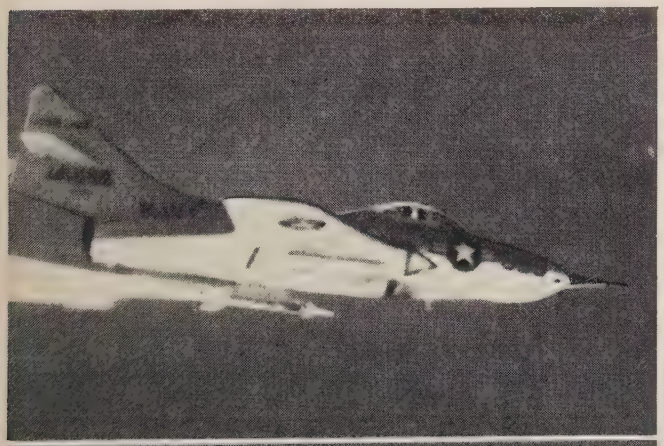
John Byrne heads highly classified advanced study and develop- mental work on a wide variety of military contracts at Motorola's Systems Research Laboratory, Riverside, California.

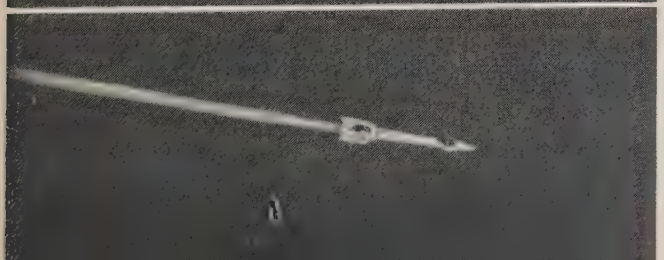


Development of passive seeker by Motorola, Riverside, is under contract to the Signal Corps for use with U.S. Army drones capable of performing night, day, and all-weather surveillance.



Motorola's surging capabilities in the solid state electronics art is achieving new dimensions in complexity, perform- ance and reliability for new electronic concepts.





Motorola is making significant design contributions to advanced guidance head for Sidewinder air-to-air missile which is under fabrication at Phoenix laboratories.

Inspection, the eyes of quality control, helps convert experience into reliability at Motorola.

AN/SSQ-23 Sonobuoys for the anti- submarine warfare program in volume production at Motorola Chicago.

REC's NEW DEICED TEMPERATURE PROBE

This extraordinary new Model 102D gives accurate total temperature measurement *while* deicing heater operates

The unique ability of this probe to permit precise total temperature measurements *while* deicing heat is continuously applied opens up numerous possibilities. Model 102D will deice within one minute when subjected to icing conditions defined in Section 3.5, paragraph g of MIL-P-25632A (USAF). Model 102D is designed for use at flight speeds up to Mach 3.

For very low drag, the 102D probe can be mounted inside a wing or tail leading edge.

NEW CATALOG. NO. 115811. Illustrated compilation of data on over 50 different REC probes ranging from −260° C. to 1500° C., plus REC pressure transducers and pitot-static tubes.

REC

ROSEMOUNT ENGINEERING COMPANY

4920 West 78th Street • Minneapolis 24, Minn.

Write in No. 217 on Reader Service Card at start of Product Preview Section

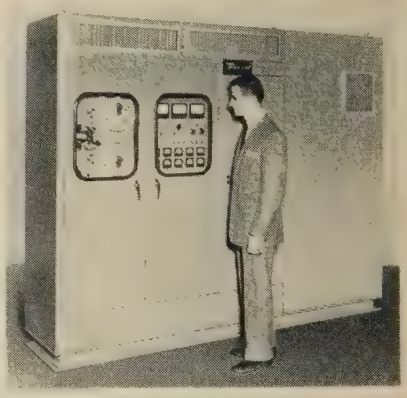
FASTENER *eliminates rivets*

This adjustable pawl fastener eliminates the rivets or bolts usually required to hold the fastener body to door or panel. One 9/16 in diameter hole takes the fastener shaft, another .082 in diameter hole receives a stop pin on the fastener to prevent it from rotating, says **South Chester Corp., Dept. S/A, Lester, Pa.** The No. 48 fastener automatically adjusts its pawl position to accommodate variations in frame thickness up to ¼ in.

It is supplied in 3 types for frame thickness up to ¼ in, ¼ to ½ in, and ½ to ¾ in.

Write in No. 339 on Reader Service Card

MACHINE UNIT *controls rotation*



This machine control is designed for switchable simultaneous continuous control of 3 out of 4 motions of rigid, high accuracy 4-axis milling machines. It provides the normal 3 axis of control says **Bendix Aviation Corp., Industrial Controls Sect., Dept. S/A, Wyoming Ave., Detroit 37, Mich.** It is able to switch from a linear motion to a rotary table or tilting spindle.

It is said that numerical machining of complex shapes are facilitated, including turbine parts, camps, aircraft and missile bulkheads.

Write in No. 340 on Reader Service Card

LIGHTWEIGHT MOTOR *for continuous duty*

This lightweight continuous duty 4.0 hp, 400 cycle ac motor has a rating of 3250 rpm, 3 phase, 200v, weighs 18.3 lbs, is 9.25 in long and 6.375 in high, according to **Hoover Electric Co., Dept. S/A, Hangar Two, Port Columbus Airport, Columbus 19, O.** Operation is up to 65,000 feet.

Application is for high starting torque in piston type high pressure compressors, hoists, pumps, antenna drives, hydraulic pumps, etc. It is designed to motor specification MIL-M-7969B (ASG) and environmental specification MIL-E-5272A.

Write in No. 341 on Reader Service Card

COSTRUZIONI AERONAUTICHE

Cascina Costa, Gallarate, Italy **G. AGUSTA**

Agusta A.Z.8 Four Engine Transportation

√ —Engines: four, 600 HP, Alvis Leonided 531/1

√ —Low purchase cost

√ —Minimal cost for operation and maintenance

√ —Landing and take-off from grass fields and sod runways

√ —Exceptional flying and safety characteristics

"A modern machine at your service for economical transportation"

. . . . . 50 Years of Experience in the Aircraft Industry

Write in No. 218 on Reader Service Card at start of Product Preview Section

data preview

ENCAPSULATION CUPS — The advantages, economy and reliability offered by the EC line of rectangular, round and diamond-shape encapsulation cups made of Diallyl Phthalate material have been discussed in catalog and processing technique sheets issued by **Electronic Production & Development, Inc., Dept. S/A, 205 S. Beverly Dr., Beverly Hills, Calif.** The cups are suitable for both air-borne and ground-based applications.

Write in No. 342 on Reader Service Card

FACILITIES—A brochure that presents information on research and service facilities for the benefit of design, production and application engineers has been prepared by **Canadian Westinghouse Co., Dept. S/A, Hamilton, Ontario, Canada.** Facilities available include an environmental laboratory, component testing section, antenna range, and computation section.

Write in No. 343 on Reader Service Card

AIR DUCTING—Two types of air ducts for the aircraft industry, both of which are wire supported and bound with glass cord, have been described in separate data sheets by **Orchard Industries, Inc., Dept. S/A, Hastings, Mich.** Data Sheet 113 covers the Neoflex type, which uses two-ply neoprene on fiberglass, and Data Sheet 114 concerns Silflex, which uses two-ply silicone on fiberglass.

Write in No. 344 on Reader Service Card

CHEMICAL MILLING—"Better Chemical Milling Through Research" is a four-page brochure that briefly describes research, consulation and production services for chemically milled parts, as performed by **Chemical Milling International Corp., Dept. S/A, 1330 E. Franklin Ave., El Segundo, Calif.** Capabilities, personnel and facilities are among the factors touched upon.

Write in No. 345 on Reader Service Card

ENVIRONMENTAL TESTING — A catalog illustrating and describing a series of temperature and humidity chambers ranging from a 2 cu ft portable unit up to a 10 cu ft production testing model has been issued by **Harris Refrigeration Co., Dept. S/A, 308 River St., Cambridge 39, Mass.** Also shown are a high-low temperature chamber with humidity control, a large chamber type that provides a cold shock temperature cycling test, an automatic high-low temperature testing, and a special chilling chamber.

Write in No. 346 on Reader Service Card

TEXTURED METALS—A six-page illustrated brochure on the mechanical metal working technique of texturing has been issued by **Ardmore Products, Inc., Dept. S/A, 129 Aldene Rd., Roselle, N.J.** The process, which contributes strength as well as design to metal, has application in a large variety of industries.

Write in No. 347 on Reader Service Card

BLIND RIVETS—A catalog illustrating and describing the low-driving-load drive-pin blind rivets has been issued by **Deutsch Fastener Corp., Dept. S/A, P. O. Box 61072, Los Angeles 61, Calif.** Included are engineering specifications, design solutions and driving sequence data.

Write in No. 348 on Reader Service Card

REGULATORS—Lightweight missile regulators are described in a detailed data sheet by **Linde Co., Dept. S/A, Room 2840, 420 Lexington Ave., New York 17, N.Y.** Called form 1237, it explains the standard instruments and various special designs.

Write in No. 349 on Reader Service Card

SUBMINIATURE CONNECTORS—Detailed catalog sheets, with specifications and dimensional drawings, showing a series of subminiature connections have been issued by **U.S. Components, Inc., Dept. S/A, 454 E. 148th St., New York 55, N.Y.** Included are standard hooded SMI-H2SL series and standard hoodless knob-type SMI-K2SL series.

Write in No. 350 on Reader Service Card

SPECIFIC-GRAVITY INDICATORS—Specific-gravity indicators for continuous measurement of liquid specific gravity are described in bulletin 18S by **Schutte & Koerting Co., Dept. S/A, Cornwells Heights, Bucks Co., Pa.** It contains construction details, plus dimensional and cross-sectional drawings.

Write in No. 351 on Reader Service Card

MAGNESIUM HYDRIDE — A general discussion of the metal hydrides, together with sections covering properties, reactions, uses and handling precautions for magnesium hydride, makes up a 16-page technical bulletin available from **The Dow Chemical Co., Dept. S/A, Midland, Mich.** Magnesium hydride can be used for captive hydrogen for foaming, active hydrogen for drying, a reducing agent, and energy for propellants or explosives.

Write in No. 352 on Reader Service Card

REFRIGERATION UNITS—A four-page technical bulletin describing refrigeration-condensing units and components has been prepared by **Task Corp., Dept. S/A, 1009 E. Vermont Ave., Anaheim, Calif.** It details ½ and ¼ horsepower units for airborne specifications.

Write in No. 353 on Reader Service Card

GROUND SUPPORT—Ground support and material handling equipment is discussed in a booklet by **Saginaw Products Corp., Dept. S/A, 68 Williamson Rd., Saginaw Mich.** It contains line drawings and photographs describing a variety of specialized uses for different types of wheels, casters, assemblies, trucks and trailers, retractable casters, leveling jacks, actuators and conveyors.

Write in No. 354 on Reader Service Card

CERAMIC PRODUCTS — Some sixty chemicals, metals and minerals for use in the ceramic, electronic and other fields are described in the 12-page Products List, prepared by **Foote Mineral Co., Dept. S/A, 18 W. Chelten Ave., Philadelphia 44, Pa.** Lithium, electromanganese, zirconium, nickel, cobalt ferro alloys, and metal powders are included.

Write in No. 355 on Reader Service Card

FERRITE DEVICES — Catalog sheets summarizing data on coaxial ferrite isolators and Tee ferrite circulators have been issued by **Sylvania Electric Products, Inc., Dept. S/A, 1740 Broadway, New York 19, N.Y.** One sheet includes 23 types of isolators covering frequencies from one to 11 kmc, and with isolation between ten and 35 db; the other describes circulators as small as one-fourth the size of conventional types and offering 20 db isolation at 0.3 db insertion loss from 5.925 to 6.425 kmc.

Write in No. 356 on Reader Service Card

ALLOY—Elgiloy an alloy with a corrosion resistance better than stainless steel and set and fatigue resistance superior to carbon steel has been described in a 24-page handbook issued by **Abrasives Div., Elgin National Watch Co., Dept. S/A, Elgin, Ill.** The alloy has non-magnetic qualities that make it ideal for instrument applications, offers greater spring power with decreased spring size, maintains spring characteristics up to +1000 deg F, and is useful for ball bearings, torsion bars, and stamped and machined parts.

Write in No. 357 on Reader Service Card

more on page 295

"Hound dog" makes a B-52's shadow broader than the state of Texas

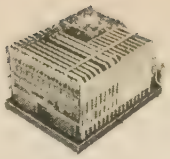
Those sharp-nosed missiles slung close to the fuselage beneath the wings of a SAC B-52 intercontinental bomber are GAM-77 HOUND DOGS with a range of several hundred miles apiece. Thus equipped, the B-52 can reach out to blast enemy resistance points over a huge area along the route to its central target.

In actual combat the inertial guidance systems in the missiles would be fed their target locations, then the missiles would be released to find their way to target at supersonic speed. Locked on target from the time of leaving the "mother ship," the missiles could be neither jammed nor decoyed.

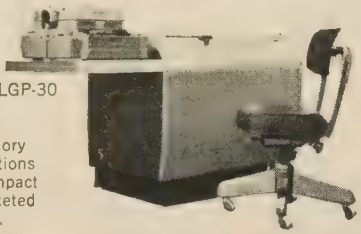
Hound Dogs are now rolling off the production lines into flight test. Alternate missiles are being assigned to a crew, half of which consists of USAF men. This is part of the Air Force's "Blue Suit Integration Program."

The Missile Division of North American Aviation is the weapon system contractor for the GAM-77.

MISSILE DIVISION
NORTH AMERICAN AVIATION, INC.
Downey, California



In the missile: small transistorized general purpose digital computer for flight control and guidance. 2000-word magnetic-drum memory.



On the ground: LGP-30 general purpose computer with 4096-word memory for such applications as design and impact prediction. Marketed by Royal McBee.

At every stage, the success of a missile program depends upon a computer. Librascope computers, components, instruments and systems give right answers from original concept to final evaluation.

THE FIRST STAGE: Workable designs. **SECOND STAGE:** Trajectory and engineering computations required long before the launching. **THIRD STAGE:** Control, guidance; impact prediction. **FOURTH STAGE:** Data reduction and analysis. ■ Recognizing still a fifth stage, Librascope determines reliability in the lab. Environmental tests check equipment for temperature, shock, vibration, pressure and other "real" conditions likely to affect performance. Only positive answers will release Librascope equipment for field use.

MISSILE COMPUTERS

right answers when you need them!

For information on career opportunities at Librascope, write Glen Seltzer, Employment Manager.

Librascope's technical ability to meet exacting requirements has ably served our many military customers in the development of missile programs. ■ For further information on Librascope's computer capabilities for missiles write:

LI 9-9

LIBRASCOPE

A GENERAL PRECISION COMPANY

LIBRASCOPE, INC. • 808 WESTERN AVENUE • GLENDALE, CALIF. • *A Subsidiary of General Precision Equipment Corporation*

Write in No. 219 on Reader Service Card at start of Product Preview Section

Here's a *NEW* FILTER ELEMENT that *FORBIDS* MEDIUM MIGRATION

From SKINNER — a name famous in filtration since 1927 — comes a unique, high temperature filter element for high performance aircraft and missile applications. A unique acid resistant braze and fabrication method whips the problems of acid compatibility and restricted temperature ranges. Temperature limits are from —400 F to 1800 F in continuous fluid-operating ranges. *No filter medium migration.* A smaller envelope is another advantage of this highly efficient element. Any type of housing applicable and delivery is immediate. If you have a filtering problem, write Skinner . . .

SKINNER FILTER

DIVISION OF

hydrodyne CORPORATION

7350 Coldwater Canyon, No. Hollywood, Calif.
Phone: POplar 5-8001

Write in No. 220 on Reader Service Card

DATA PREVIEW

PRECISION COMPONENTS — A 416 page master catalog No. 20, listing more than 10,000 items, including gears, shafts, collars, couplings, speed reducers, differentials and other precision items, has been prepared by **PIC Design Corp., Dept. S/A, 477 Atlantic Ave., E. Rockaway, L. I., N. Y.** It contains detailed drawings, specifications, technical data, breadboard kit and precision tool components sections.

Write in No. 358 on Reader Service Card

FILTER ASSEMBLIES—Two lines of standardized T-type in-line filters and replacement elements for high and low pressure applications are described in literature prepared by **Bendix Aviation Corp., Filter Div., Dept. S/A, 434 W. Twelve Mile Rd., Madison Heights, Mich.** Included are details on rating, specifications and applications.

Write in No. 359 on Reader Service Card

UNGEARED MOTORS — Performance characteristics, ratings, construction, dimensions and applications for four types of ac shaded pole, reversible, ungeared motors are discussed in Catalog R-1 by **Barber-Colman Co., Small Motors Div., Dept. S/A, Rockford, Ill.** It also covers electronic control of reversible motor.

Write in No. 360 on Reader Service Card

CAPACITORS—A new 46-page capacitor catalog, said to be one of the most complete ever published, is available from **Good-All Electric Mfg. Co., Dept. S/A, 112 W. First St., Ogallala, Nebr.** The publication covers Good-All's entire line of tubular, ceramic disc and subminiature electrolytic capacitors.

Write in No. 361 on Reader Service Card

TEST CABINET—A precise environmental test cabinet with program control, producing a variety of climatic conditions for various types of product testing is described in Catalog No. 55 by **American Instrument Co., Inc., Dept. S/A, 8030 Georgia Ave., Silver Spring, Md.** The apparatus uses a cam-operated recording controller to maintain proper temperature and humidtiy automatically.

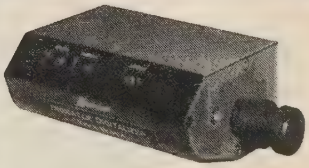
Write in No. 362 on Reader Service Card

ALLOY—Technical data on RA 330, a heat-resisting alloy with a melting range of 2550 to 2600 deg F, have been presented in Bulletin 107, available from **Rolled Alloys, Inc., Dept. S/A, 5309 Concord, Detroit 11, Mich.** Included are facts on chemical composition, stress rupture properties, short time high temperature properties, oxidation resistance, and recommended design stresses.

Write in No. 363 on Reader Service Card

more on page 297

BASIC BUILDING BLOCKS FROM KEARFOTT



TIME INDEX DIGITALIZER

This visual analog-to-digital converter (VADAC) displays time values in hours, minutes and seconds and simultaneously transmits this information as a coded electrical signal by means of coded drum assemblies and pick-off brushes. Driving pulse advancing drums and interrogating pulses for digital readout are provided from external, user-supplied source.

TYPICAL CHARACTERISTICS

- Range: 00 00 00 to 23 59 59 hrs.
- Input Pulse Frequency: 1/sec.
- Input Pulse Form: Square
- No. of Visual Output Counter Wheels: 5
- Numeral Color: White on Black
- Code: Binary decimal
- Step Time: 30 msec.max. 15 msec.min.
- Operating Position: Any plane
- Brush Load: 50 ma. 40 VDC
- Operating Temperature Range: —54°C +77°C
- Humidity Resistance: per MIL-E-5272A, Proc. 1
- Vibration Resistance: per MIL-E-5272A, Proc. 1
- Shock Resistance: per MIL-E-5400, para. 3.2.20.2.1
- Weight: 1.75 lbs.
- Operating Life: 1000 hrs.

Write for complete data.

Kearfott | A GENERAL PRECISION COMPANY

KEARFOTT COMPANY, INC., LITTLE FALLS, N. J.
A subsidiary of General Precision Equipment Corporation
Sales and Engineering Offices: 1500 Main Ave., Clifton, N. J.
Midwest Office: 23 W. Calendar Ave., La Grange, Ill.
South Central Office 6211 Denton Drive, Dallas, Texas
West Coast Office 253 N. Vinedo Avenue, Pasadena, Calif.

Write in No. 221 on Reader Service Card

GPL research

Nuclear Gyros

GPL research is now studying for the U.S. Air Force, the feasibility of harnessing the most efficient gyro known to science—the nucleus of the atom. Development of such a gyro—tremendously accurate, perfectly balanced, friction and maintenance free—will revolutionize space reference, navigation and guidance techniques.

The nuclear gyro is just one of many programs now underway at GPL research. Others include:

Soft landings on the moon • Passive position fix taking • Maser amplifiers • Pulsed radar seekers • Electrically scanning radar antennas • Space velocity measuring systems • "Multi-Mode" airborne systems • Obstacle and terrain clearance radar • Advanced digital and data handling techniques

These, plus continuing research in radar, computer and data handling theory, reflect a part of the breadth of GPL's enlightened investment in the future.

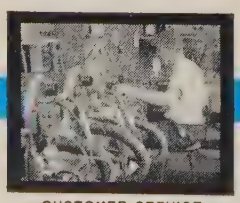
Write for further information.

GPL Avionic Division/airborne navigators/missile guidance/ radar/airborne computers/data handling systems/ communications equipment/infra-red/closed circuit TV.

ENGINEERS — GPL achievements have opened a number of challenging research and development opportunities. To be considered for these career positions, send resume of previous experience to Personnel Director.

MANUFACTURING

ENVIRONMENTAL TESTING



CUSTOMER SERVICE

RESEARCH / ENGINEERING / FLIGHT TESTING

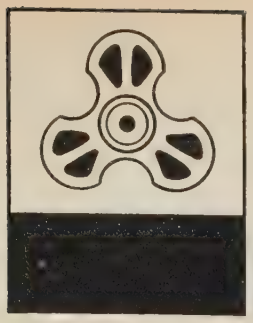
GPL

A GENERAL PRECISION COMPANY

GENERAL PRECISION LABORATORY INCORPORATED, Pleasantville, N. Y.

A Subsidiary of General Precision Equipment Corporation

Write in No. 222 on Reader Service Card at start of Product Preview Section



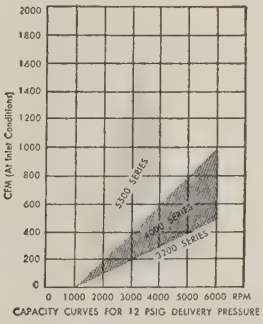
3-LOBE DESIGN

Exclusive M-D 3-lobe design adds strength—reduces torsion. Dynamically balanced rotor permits higher speeds —greater pressures.

Why M-D rotary positive blowers develop higher pressures . . .

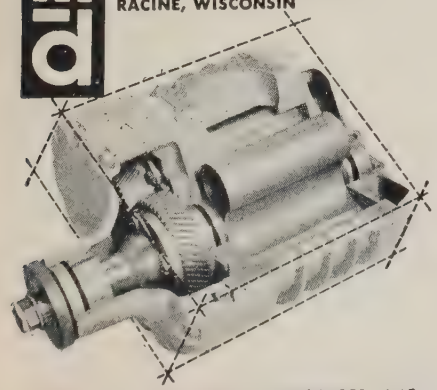
The unique combination of precision manufacture and modern design found only in M-D rotary positive blowers permits higher speed operation and higher pressures. For this reason M-D can furnish greater air flow at lower initial cost.

M-D blowers operate at wider pressure and speed ranges than any other rotary positive blower. Capacities of 22 production models range from 50 to 4,000 CFM, pressures to 14 PSIG single, 70 PSIG multi-stage.



CAPACITY CURVES FOR 12 PSIG DELIVERY PRESSURE

M-D BLOWERS, INC.
RACINE, WISCONSIN



A SUBSIDIARY OF MIEHLE-GOSS-DEXTER, INC.

Write in No. 223 on Reader Service Card

DATA PREVIEW

RADIAL BALL BEARING—Ball bearings for applications demanding sustained performance under especially heavy radial loads are described in a bulletin No. 107 by **Hoover Ball & Bearing Co., Dept. S/A, 5400 S. State Road, Ann Arbor, Mich.** It describes bearings made in light, medium and heavy series and includes dimensional and load rating data.

Write in No. 364 on Reader Service Card

CAP SCREWS—Tables of dimension standards, comparisons of head diameter, bearing surface, tensile load to indent soft steel, and other factors for hex socket cap screws are contained in Bulletin G-25 of **Allen Mfg. Co., Dept. S/A, Hartford 1, Conn.**

Write in No. 365 on Reader Service Card

TEST TURNTABLE—Detailed description of features and specifications of Model 031 variable rate test turntable are contained in a bulletin by **J. W. Fecker, Inc., Dept. S/A, 6592 Hamilton Ave., Pittsburgh 6, Pa.** Electrical and dimensional block diagrams are shown.

Write in No. 366 on Reader Service Card

ALLOY WIRE—Folders designed for the engineer contain physical, chemical and electrical properties of special purposes wire have been issued by **Little Falls Alloys, Inc., Dept. S/A, 189 Caldwell Ave., Paterson, N. J.** A chart shows size, tensile strength, and composition.

Write in No. 367 on Reader Service Card

AUTOMATIC TRACING—A fully automatic 3D programmed control system for milling applications is described in bulletin STM-1 by **True-Trace Sales Corp., Dept. S/A, 9830 Rush St., El Monte, Cal.** Other features described include uniform feed rate, even on 90° walls, "pick" in either direction and reduced benching time.

Write in No. 368 on Reader Service Card

FREQUENCY METER—The Model 211R, a digital frequency meter with built-in inline-inplane readout, has been discussed in a technical brochure by **Computer Measurements Corp., Dept. S/A, 5528 Vineland Ave., North Hollywood, Calif.** The device measures and displays frequencies to 220 kc and periods to 100 kc.

Write in No. 369 on Reader Service Card

ROTATING PARTS—A catalog of small AC motors and rotating components according to military and commercial specifications has been published by **Rotating Components, Inc., Dept. S/A, 267 Green St., Brooklyn 22, N. Y.** It includes axial fans, cooling cabinets, servo and gear motors, etc.

Write in No. 370 on Reader Service Card

more on page 299

BASIC BUILDING BLOCKS FROM KEARFOTT

PRECISE ANGLE INDICATOR

Consisting of an angle position indicator, motor and servo amplifier, this small, versatile, rack panel mounted unit provides angular position indications for laboratory, production and field use. Input signals proportional to unknown angular position of synchro device being measured are resolved as an error voltage, which is amplified and used to drive an internal servo loop to null. Counter mechanism then provides direct visual readout of angular position.

TYPICAL CHARACTERISTICS

Input Signal: S_1, S_2, and S_3 of external synchro transmitter.

Repeatability: Within 0.6 minute in either a clockwise or counterclockwise direction for any angular position.

Readability: 0.5 minute through full range from zero to 360° Rotation is continuous.

Accuracy: ± 6 minutes in the standard unit. Other accuracies available on request.

Sensitivity: 0.5 minutes maximum.

Slewing Speed: Phase sensitive, 180° in 7 seconds.

Input Voltages: 115 volts, single phase, 400 cycles, 23 VA max.

Size: Standard Rack Mounting—1¾" x 9½" x 8½"

Write for complete data.

Kearfott — A GENERAL PRECISION COMPANY

KEARFOTT COMPANY, INC., LITTLE FALLS, N. J.
A subsidiary of General Precision Equipment Corporation
Sales and Engineering Offices: 1500 Main Ave., Clifton, N. J
Midwest Office: 23 W. Calendar Ave., La Grange, Ill
South Central Office: 6211 Denton Drive, Dallas, Texas
West Coast Office: 253 N. Vineda Avenue, Pasadena, Calif

Write in No. 224 on Reader Service Card

Some Properties of "K" Monel alloy at Low Temperatures

Condition	Temp. °F.	Yield Strength 0.2% Offset psi.	Tensile Strength psi.	Elongation % in 2 in.	Reduction in Area %
Cold-drawn, age-hardened	Room*	120,000	160,000	20.0	35.0
Cold-drawn, age-hardened	−110	134,600	171,550	17.3	41.1
Cold-drawn, age-hardened	−300	160,200	202,000	27.0	47.3

Nominal values

Gets tougher and stronger as temperatures go down

"K" Monel alloy also resists oxidation and corrosive attack

In "K" Monel* age-hardenable nickel-copper alloy, the missile designer has a highly useful material for combined strength, ductility and corrosion resistance at extreme low temperatures . . .

This heat treatable alloy starts with high strength and ductility and improves as temperatures drop to −300°F. Consequently "K" Monel components, whether made by forging, welding, or from common mill forms like tubing, perform as well or better at −300°F than at room temperature.

You can add other outstanding properties to the list, too. For instance, "K" Monel alloy has excellent resistance to oxidizers and many types of corrosives.

This same alloy, unlike many non-ferrous materials, also has high heat resistance . . . good strength and ductility and excellent corrosion resistance well into the 1000°-1200°F range.

Other excellent low . . . and high . . . temperature alloys

Other Huntington Alloy Products, such as Monel* nickel-copper and Inconel* nickel-chromium alloys for example . . . provide excellent combinations of strength, ductility and toughness at low temperature.

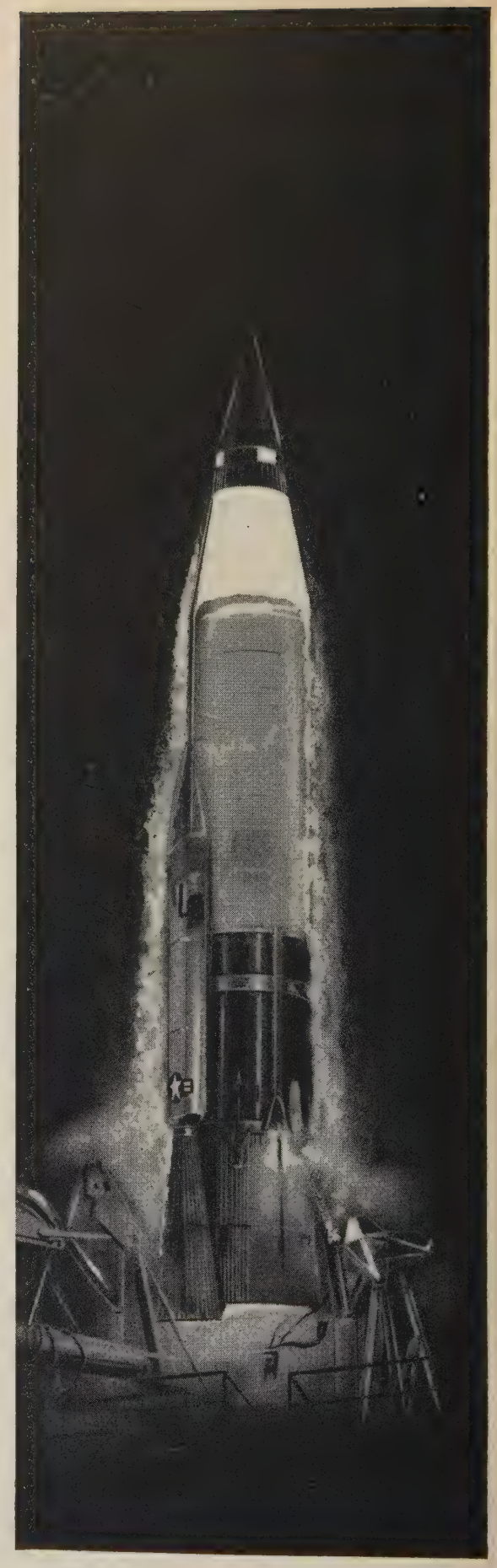
Huntington Alloy Products Division also provides a number of new alloys specially developed for extremely high temperatures . . . Inconel "713C",* a nickel-chromium cast alloy, Inconel "702",* an aluminum-containing nickel-chromium alloy, and Inconel "700",* an age-hardenable nickel-cobalt-chromium alloy. And it's worth noting that these alloys are high performance materials at low temperatures.

For information on low-temperature properties of these standard production alloys, send for "Some Properties of Huntington Alloys at Low Temperatures." Ask about the new high-temperature alloys, too . . . if that's where your special interest lies.

*Inco trademark

HUNTINGTON ALLOY PRODUCTS DIVISION

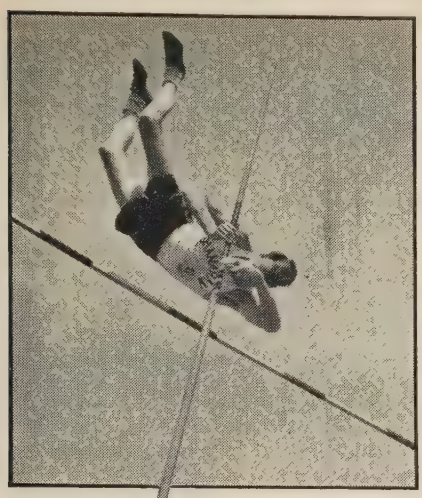
The International Nickel Company, Inc.
67 Wall Street New York 5, N. Y.



"K" MONEL®

Write in No. 225 on Reader Service Card at start of Product Preview Section

TOPS 'EM ALL



IN QUALITY OF TUBING

Comparative quality tests by one of America's leading users of tubing proved only Precision Tubing rates excellent in all specifications . . . yet Precision Tubing costs no more.

Precision Tubing is unequalled and unsurpassed in quality tests of accuracy, temper, straightness and roundness. You are sure of extra quality in every size tube at regular mill prices. Available in sizes from .010" to 1.125" O.D. in copper, brass, aluminum, up to ⅝" O.D. in nickel and nickel alloys, Ni-Span "C", phosphor bronze and nickel silver. In straight random lengths, coils or preformed shapes to specifications.

Write for catalog and technical data to Dept. 9, Precision Tube Company, Inc., North Wales, Pa.

GET THIS NEW TUBING DATA CATALOG

PRECISION TUBE COMPANY

Write in No. 226 on Reader Service Card

DATA PREVIEW

SERVO MOTOR—Technical data on the use of inertia and velocity damped servo motors is contained in a booklet by **Beekman Instruments, Inc., Dept. S/A, 2500 Fullerton Rd., Fullerton, Calif.** Transfer function equations are given.

Write in No. 371 on Reader Service Card

SWITCH—A rotary switch with wafers that lift out instantly without unsoldering or disassembling for cleaning or instant replacement is described in a brochure by **Chicago Dynamic Industries, Dept. S/A, 1725 Diversey Blvd., Chicago 14, Ill.**

Write in No. 372 on Reader Service Card

POWER CONNECTORS—An illustrated bulletin with specifications, outline dimensions and general information on Series 14 power connectors with closed ring entry contacts has been prepared by **DeJur-Amsco Corp., Electronic Sales Div., Dept. S/A, 45-01 Northern Boulevard, L. I. City 1, N. Y.**

Write in No. 373 on Reader Service Card

SOLENOID VALVES — Bronze and stainless steel solenoid valves, with specifications, performance data, and applications are discussed in Catalog 444 by **Atkomatic Valve Co., Dept. S/A, 545 West Abbot St., Indianapolis, Ind.** Cutaway drawings are included.

Write in No. 374 on Reader Service Card

CAPACITORS—A 6-page folder describing the remarkable "tough" qualities of El-Menco Ceramic Disc Capacitors can be obtained by writing to **Electro Motive Mfg. Co., Inc., Dept. S/A, Willimantic, Conn.** It includes complete specifications data, charts, and graphs on the performance capabilities of their line of capacitors.

Write in No. 375 on Reader Service Card

MISSILE FLUID CONTROLS—A new bulletin on Fluid Control Systems for missiles is available from **Koehler Aircraft Products Co., Dept S/A, 409 Leo St., Dayton, Ohio.** Described and illustrated in this two-color bulletin are typical valves, accessories and control systems for the in-flight and ground support handling of oils, fuels, oxidizers and liquid or gaseous coolants.

Write in No. 376 on Reader Service Card

ASSEMBLY DESIGN — PIC Design Corp., Dept. S/A, 477 Atlantic Ave., East Rockaway, L.I., N.Y., has issued a booklet outlining a new engineering concept in the design of servo-mechanism gear train packages. The use of Stock Instrument plates and cluster gears in providing low-cost precision assemblies with a minimum of design and engineering time, is featured.

Write in No. 377 on Reader Service Card

more on next page

BASIC BUILDING BLOCKS FROM KEARFOTT

Size 8

INTEGRATING MOTOR GENERATOR

This high performance unit is the smallest of its type available today. Accurate in the Kearfott tradition, this motor generator is thermistor compensated and characterized by an output of .5V/1000 RPM, linearity of .06% from 0-3600 RPM and output variation of temperature (—15°C to +75°C) of ±.4% from the value at 25°C.

TYPICAL CHARACTERISTICS

MOTOR SECTION	Phase 1	Phase 2
Voltage (volts)	26	40
Frequency (cps)	400	400
*Current (amp)	.119	.077
*Power Input (watts)	2.3	2.3

GENERATOR SECTION

Excitation: 26 V., 400 cps, .067 amps., 1.4 watts.

Volts @ 1000 RPM	.5
Phase Shift @ 3600 RPM	0°
In Phase Axis Error (mv)	1.5
Quadrature Axis Error (mv)	3
Linearity @ 3600 MPH (%)	.06

*Values measured at stall

MECHANICAL CHARACTERISTICS

Weight (Oz.)	3.9
No Load Speed (RPM)	5500
Stall Torque (Oz.)	0.22

Write for complete data.

Kearfott | A GENERAL PRECISION COMPANY

KEARFOTT COMPANY, INC., LITTLE FALLS, N. J.

A subsidiary of General Precision Equipment Corporation

Sales and Engineering Offices 1500 Main Ave., Clifton, N. J.
Midwest Office 23 W. Calendar Ave., La Grange, Ill.
South Central Office 6211 Denton Drive, Dallas, Texas
West Coast Office 253 N. Vinedo Avenue, Pasadena, Calif.

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NEW MINIATURE PRESSURE TRANSDUCER BY COLVIN

- Only one inch square – one inch long
- Withstands high vibration

35 G to 5000 CPS 0-3 to 0-400 psi
400 to 10,000 ohms

AVAILABLE IMMEDIATELY

COLVIN LABORATORIES, INC.
364 Glenwood Avenue East Orange, N. J.

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THERMOCOUPLE WIRE—A new line of thermocouple wires has been described in a four-page catalog issued by **Harco Laboratories, Inc., Dept. S/A, 77 Olive St., New Haven, Conn.** Information on gauge, type, color coding, and insulation combinations is tabulated.

Write in No. 378 on Reader Service Card

VOLTMETER—The Model 502 ac/dc digital voltmeter, which features a fifth digit for dc overranging has been described in Data Sheet 19-41 by **Cohu Elctronics, Dept. S/A, Box 623, San Diego, Calif.** The fifth digit in the three unit system prevents loss of resolution at the range changeover points and gives much the same accuracy as a five-digit instrument.

Write in No. 379 on Reader Service Card

CHECK VALVE—Detailed information and specifications for a new, spring-loaded controllable check valve is available in a data sheet issued by **Fluid Regulators Corp., Dept. S/A, 313 Gillette St., Painsville, O.** The valve requires a low mechanical force to unload and provides positive control of systems in ground support and other exacting applications.

Write in No. 380 on Reader Service Card

METAL STAMPINGS—A brochure describing facilities for producing deep drawn parts and metal stampings to customer specification has been prepared by **Peterson Products Corp., Dept. S/A, 4840 River Rd., Schiller Park, Ill.** Types of press equipment and capacities are in chart form.

Write in No. 381 on Reader Service Card

MICROPHONICS—The techniques of exciting and measuring the microphonics of vacuum tubes have been described in the 16-page "Technical Review No. 4," available from **B & K Instruments, Inc., Dept. S/A, 3044 W. 106th St., Cleveland 11, O.** Tube reliability in several environments is considered.

Write in No. 382 on Reader Service Card

TAPE LOOP RECORDER—The Type 5-781 magnetic tape continuous-loop recorder/reproducer has been described in the four-page Bulletin 1614 available from **Consolidated Electrodynamics Corp., Dept. S/A, 360 Sierra Madre Villa, Pasadena, Calif.** The device records and reproduces data on loops at continuously adjustable lengths from two to 75 ft and at speeds from 1 7/8 through 60 ips.

Write in No. 383 on Reader Service Card

more on page 302

CIRCUIT DESIGN ENGINEERS NEEDED

IN SOUTHERN CALIFORNIA

Bendix-Pacific

the major source for instrumentation systems and components, offers you a unique opportunity to fully use your ability with a rewarding future as a qualified engineer.

Have you had two or more years experience in the design of VHF or UHF transmitters?

. . . in airborne packaging?

. . . in transistor circuitry?

If you have, we want to talk to you.

Please send resume to **W. C. WALKER**
ENGINEERING EMPLOYMENT MANAGER

Bendix-Pacific
DIVISION OF BENDIX AVIATION CORPORATION

NORTH HOLLYWOOD, CALIFORNIA

Other High-Level Electronic Engineering Positions Available

Check Employment Inquiry Form on Page 195

BASIC BUILDING BLOCKS FROM KEARFOTT

FLOATED RATE INTEGRATING GYROS

Specifically designed for missile applications, these Kearfott miniature gyros operate efficiently at unlimited altitudes. Their outstanding accuracy and performance make them superior to any comparably-sized units on the market. Hermetically sealed within a thermal jacket, these gyros are ruggedly designed and completely adaptable to production methods. Performance characteristics that are even more precise can be provided within the same dimensions.

TYPICAL CHARACTERISTICS

Mass Unbalance:
Along Input Axis: 1.0°/ hr maximum untrimmed

Standard Deviation (short term):
Azimuth Position: 0.05°/hr
Vertical Position: 0.03°/hr

Drift Rate Due to Anisoelasticity
Steady Acceleration:
.015°/hr./g^2 maximum

Vibratory Acceleration:
.008°/hr./g^2 maximum

Damping:
Ratio of input angle to output angle is 0.2

Characteristic Time:
.0035 seconds or less

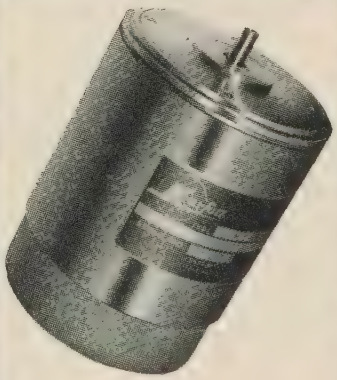
Weight: 0.7 lbs.

Warm-Up Time:
10 minutes from —60°F

Life: 1000 hours minimum

Write for complete data.

BASIC BUILDING BLOCKS FROM KEARFOTT



20 SECOND SYNCHRO

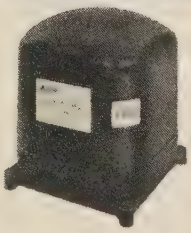
This synchro, just one of a broad line offered by Kearfott, provides the extreme accuracy required in today's data transmission systems. Kearfott synchro resolvers enable system designers to achieve unusual accuracy without the need for 2-speed servos and elaborate electronics. By proper impedance, matches up to 64 resolver control transformers can also operate from one resolver transmitter.

TYPICAL CHARACTERISTICS — SIZE 25

Type Resolver	Transmitter	Control Transformer
Part Number	Z5161-001	Z5151-003
Excit. Volts (Max.)	115	90
Frequency (cps)	400	400
Primary Imped.	400/80°	8500/80°
Secondary Imped.	260/80°	14000/80°
Transform. Ratio	.7826	1.278
Max. Error fr. E.Z.	20 seconds	20 seconds
Primary	Rotor	Stator

Write for complete data.

BASIC BUILDING BLOCKS FROM KEARFOTT



MINIATURE VERTICAL GYRO

Provides accurate vertical reference in the form of two 400 cps synchro signals proportional to sine of gimbals' displacement about pitch and roll axes. Gravity-sensitive vertical reference device provides electrical signals directly to torque motors which maintain gyro spin axis perpendicular to earth's surface. Hermetically sealed and impervious to sand, dust, sun, rain, salt, spray, humidity or fungus as specified in MIL-E-5272A.

TYPICAL CHARACTERISTICS

Free Drift Rate:
Within 0.5° in one minute time.

Shock:
The gyro operates satisfactorily without damage after 60g shock of .015 seconds duration.

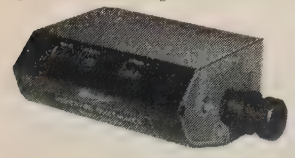
Hermetically Sealed:
These instruments are hermetically sealed and are not affected by sand, dust, sunshine, rain, humidity or fungus conditions.

Operating Temperature Range:
Gyros operate in ambient temperatures below —20°C to +100°C. A maximum of 3 minutes of operation at 400°F will not damage these gyros nor impair their accuracy.

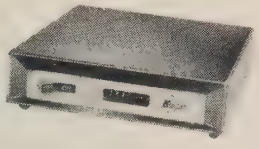
Weight:
5.5 lbs. approximately.

Write for complete data.

Time Index Digitalizer



Precise Angle Indicator



Size 8 Integrating Motor Generator

Engineers: Kearfott offers challenging opportunities in advanced component and system development.

Kearfott | A GENERAL PRECISION COMPANY

KEARFOTT COMPANY, INC., LITTLE FALLS, N. J.
A subsidiary of General Precision Equipment Corporation
Sales and Engineering Offices: 1500 Main Ave., Clifton, N. J.
Midwest Office: 23 W. Calendar Ave., La Grange, Ill.
South Central Office: 6211 Denton Drive, Dallas, Texas
West Coast Office: 253 N. Vinedo Avenue, Pasadena, Calif.

Write in No. 228 on Reader Service Card at start of Product Preview Section

1 Vari-Typer saves lettering time of 4 draftsmen!

INSTANTLY CHANGEABLE TYPE

Hundreds of faces

LETTERING MACHINE

Letters tracings even 12 feet or more wide

Hundreds of Different Styles and Sizes

Why waste your high-priced draftsmen on simple lettering jobs when your office typist, using the Vari-Typer, can do these jobs 4 times faster.

Vari-Typer Model E-24 with hundreds of instantly changeable types is especially designed to give clean, sharp lettering on tracings (cloth or paper) even 12 feet or more wide!

Here is a simply operated, cost-saving lettering machine ideal for lettering on specification sheets, forms, instruction manuals, and bills of material. Types are available with engineering and mathematical symbols.

Text by Vari-Typer. Heads by Headliner.

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DATA PREVIEW

CONNECTORS – Several new catalog sheets have been issued to describe the Floating Body Isolation miniature connectors made by **U.S. Components, Inc., Dept. S/A, 454 E. 148th St., New York 55, N.Y.** The F.B.I. Series of connectors is designed with contacts that are embedded in a plastic insulating body.

Write in No. 383 on Reader Service Card

SERVO COMPONENTS—Bulletin No. 102-58 describes predesigned mechanisms and components for the servo and instrument fields. It contains information regarding a variety of geared mechanisms for use in breadboarding and prototype, prepared by **Precision Mechanisms Corp., Dept. S/A, 577 Newbridge Ave., E. Meadow, N. Y.** Production applications may be assembled from the pictured components and the instructions.

Write in No. 384 on Reader Service Card

BORESCOPES—A data file containing illustrated descriptions of many different types of borescopes is available from **Engelhard Industries, Inc., National Electric Instrument Div., Dept. S/A, 92-21 Corona Ave., Elmhurst 73, N. Y.**

Write in No. 385 on Reader Service Card

HYDRAULICS—A brochure containing full description of the facilities for engineering, production and services at **Greer Hydraulics, Inc., Dept. S/A, International Airport, Jamaica 30, N. Y.,** has been issued by the company. Various sections discuss the firm's background in fluid systems, research and development, componentry, missiles, aircraft systems, ordnance, atomic systems, laboratories, etc.

Write in No. 386 on Reader Service Card

INSTRUMENTS – Representative instruments from standard "off-the-shelf" components to complex instrumentation systems, including data processing and calibration equipment, force instrumentation, electronic weighing units, and special recording instrumentation for strain gages and thermocouples, are described in Bulletin G-100 by **Gilmore Industries, Inc., Dept. S/A, 13015 Woodland Ave., Cleveland 20, Ohio.**

Write in No. 387 on Reader Service Card

MAGNETRONS—Details on X-, Ka-, and K-band devices are included in a magnetron catalog available from **Sylvania Electric Products, Inc., Dept. S/A, 1740 Broadway, New York 19, N.Y.** The publication lists four tunable X-band magnetrons, two with 1100-mc tuning ranges and minimum peak powers of 200 kw, and K-band types with over 100 Kw peak power levels.

Write in No. 388 on Reader Service Card

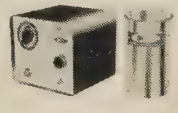
more on page 304

Narda SonBlasters...

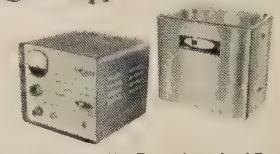
for lowest-cost, mass-produced ultrasonic cleaners!

The most complete line of ultrasonic cleaners at lowest prices in the industry, available off-the-shelf for immediate delivery. And with a full two-year warranty besides!

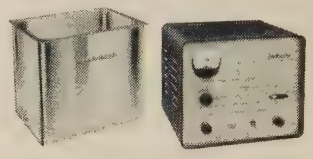
No matter what you want to clean—"hot" lab apparatus, medical instruments, electronic components, automotive, missile and avionic parts and assemblies, optical and technical glassware, timing mechanisms—Narda SonBlaster ultrasonic cleaners will do the job faster, better and cheaper! Write for more details **now** and we'll include a free questionnaire to help determine the precise model you need. Address: Dept. SA-32.



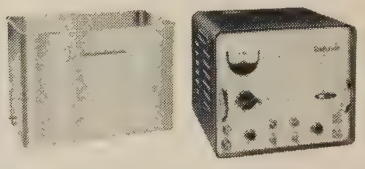
Generator G-202, 35 watts; **Transducerized Tank NT-202,** Capacity: ⅜ gallon. **$220.**



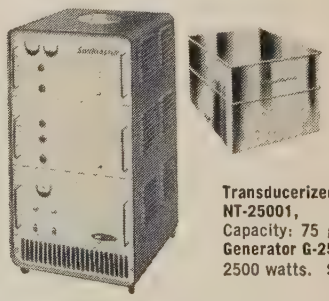
Generator G-601, 60 watts; **Transducerized Tank NT-602,** Capacity: 1 gallon. **$350.**



Transducerized Tank NT-1505, Capacity: 5 gallons; **Generator G-1501,** 300 watts. **$695.**



Transducerized Tank NT-5001, Capacity: 10 gallons; **Generator G-5001,** 500 watts. **$1325.**



Transducerized Tank NT-25001, Capacity: 75 gallons; **Generator G-25001,** 2500 watts. **$4360.**

Consult with Narda for all your ultrasonic requirements. The SonBlaster catalog line of ultrasonic cleaning equipment ranges from 35 watts to 2.5 KW, and includes transducerized tanks as well as immersible transducers which can be adapted to any size or shape tank you may now be using. If ultrasonics can be applied to help improve your process, Narda will recommend the finest, most dependable equipment available—and at the lowest price in the industry!

the narda ultrasonics corporation
625 MAIN STREET, WESTBURY, L. I., N. Y.
3259 Wilshire Boulevard, Los Angeles 5, Calif.
Subsidiary of The Narda Microwave Corp.

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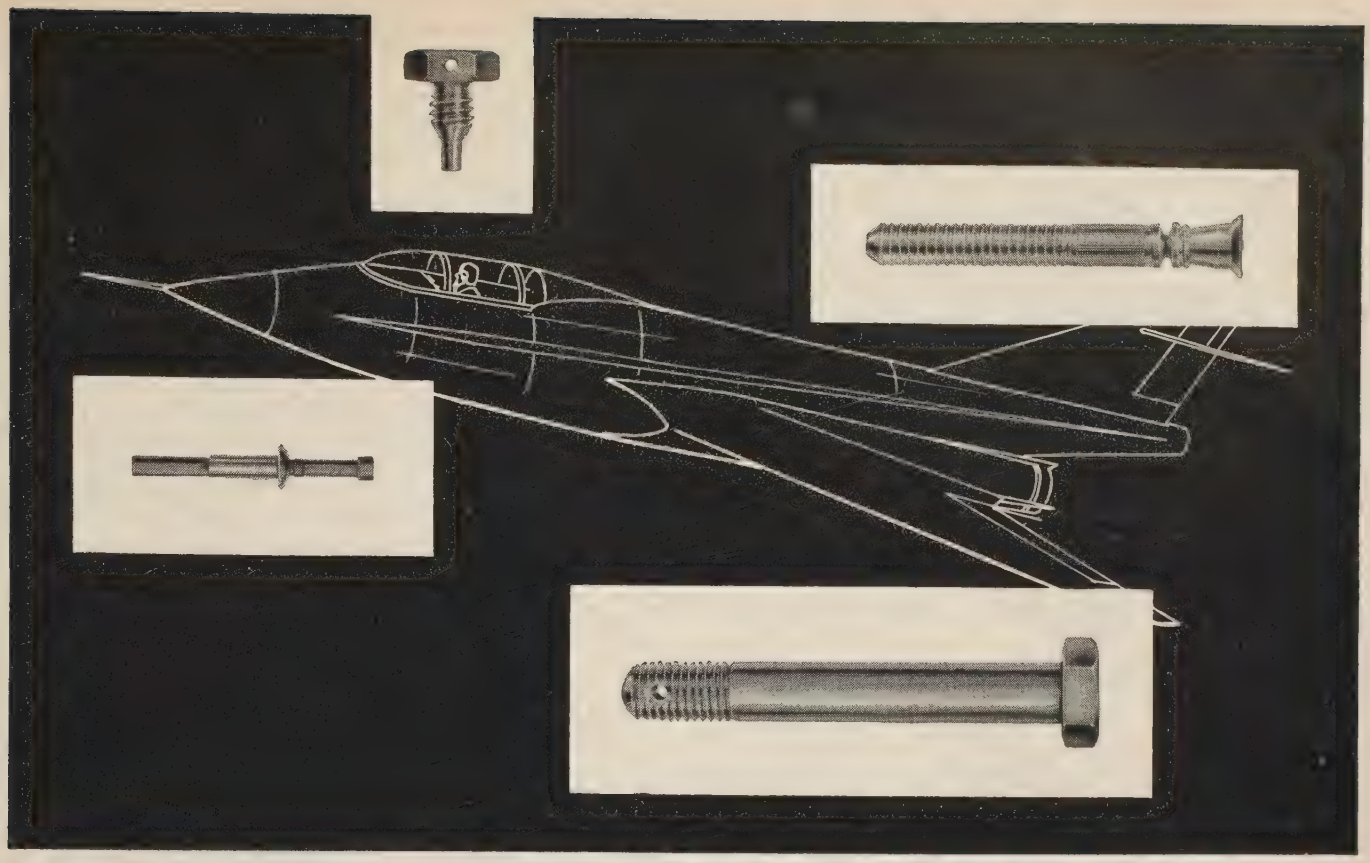

Stainless Steel fasteners provide high strength at elevated temperatures . . . add reliability to high-flying planes

Just as a chain is only as strong as its weakest link . . . a modern high speed commercial plane is only as strong as the vital fasteners that hold it together. Because of the importance and the high cost of these aircraft, every precaution is taken to make them as foolproof as possible . . . and that includes fasteners made of stainless steel wire.

Stainless steel wire made by American Steel & Wire has the strength to stand up under high temperatures and fast speeds, and under severe pressures and corrosive conditions. The four fasteners shown here, made of stainless steel wire by leading fastener producers, are typical of the many thousands of stainless steel fasteners in use in modern planes. In every case, these fasteners have added strength and serviceability to the aircraft in which they were used.

For more information on American Steel & Wire stainless steel wire, and its important application to the vital aviation industry, get in touch with American Steel & Wire. Our metallurgists will be glad to work with your fastener manufacturers to supply just the right grade of stainless steel wire to meet your requirements.

The new American Steel & Wire Stainless Steel Wire Manual is the most comprehensive ever published. To get your free copy of this outstanding manual, just write to American Steel & Wire, Room 9266, 614 Superior Avenue, N.W., Cleveland 13, Ohio.

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NOW! Automatically Control and Test Complex Electro-Mechanical Systems

with complete reliability!

If you're having trouble testing complex electro-mechanical systems, it will pay you to investigate DIT-MCO's 250F2M Electro-Mechanical Systems Analyzer. It is specially designed to control and test integrated devices and their associated wiring by simulating controlling assemblies and monitoring their action.

Each of the Analyzer's 200 test positions can perform up to 36 independent switching functions. Its capacity to control complex systems, therefore, is almost unlimited. In each test position the 250F2M will:

1. Actuate all necessary resistive devices and provide termination-to-termination tests of each circuit for continuity and discontinuity.
2. Simulate conditions which allow it to operate and test each resistive device in the circuit under test.
3. Provide for visual measurement of resistive values and time delay constants where desired.
4. Provide switching capabilities which enable monitoring of circuit conditions with external detecting devices.

These capabilities make it possible to achieve extremely high standards with complex relay chassis and similar systems, thus eliminating borderline errors which can lead to malfunction under operating conditions.

The 250F2M uses DIT-MCO's exclusive Matrix Chart to put complete circuit information right in front of the operator's eyes. The machine is easy to operate, easy to interpret, easy to adapt to any test. Write today for full details.

DIT MCO

ELECTRONICS DIVISION
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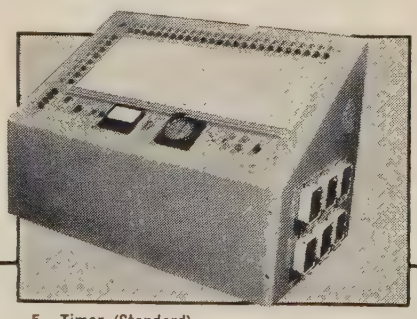
Kansas City 5, Missouri

In the Los Angeles area • In the New York City area
Ph. ORegon 8-6106 Ph. MUrray Hill 2-5844
Ph. OSborne 5-1123

Home Office Kansas City
Ph. HArrison 1-0011



SPECIFICATIONS:

1. Continuity Test
   A. Test Voltage ..... 28 V.D.C.
   B. Continuity Current ..... 1 ampere
   C. Continuity Resistance ..... adjustable from 0.3 ohms to 10 ohms
2. Continuity-Discontinuity Test
   A. Test Voltage ..... 28 V.D.C.
   B. Continuity Current ..... 1 ampere
   C. Continuity Resistance..0.3 ohms to 10 ohms
   D. Discontinuity Resistance..... 2.5 megohms reject, 3 megohms accept
3. Short Test
   A. Test Voltage ..... 28 V.D.C.
   B. Test Current ..... 0.03 ma (max)
   C. Short Resistance Range ..... 2.5 megohms reject, 3 megohms accept
4. Ohmmeter
   A. Range ..... 0 to 200 megohms
   B. Accuracy ..... ±3%
5. Timer (Standard)
   A. 60 minute range, 0.2 second scale division
   B. Accuracy..0.1 sec. per operation at 60 cycles
   Timer (Optional)
   A. 60 minute range, 0.01 second scale division
   B. Accuracy..0.002% per operation ±1 division
6. Power Requirements
   A. 100 to 125 V.A.C. 55 to 65 cycles (standard timer)
   B. 100 to 125 V.A.C. 50 to 400 cycles (optional timer)
7. External Energization
   A. 28 V.D.C. and 110 V.A.C., 60 cycles are provided for external energization of relays or other resistive devices, isolated from test voltage.
   B. Other voltages may be supplied by external power supplies and switched as external energization or other test purposes.

Write in No. 232 on Reader Service Card at start of Product Preview Section

DATA PREVIEW

TUBES—A condensed catalog that describes traveling wave tubes and several types of klystrons has been issued by **Electronic Tube Div., Sperry Gyroscope Co., Dept. S/A, Great Neck, N.Y.** The klystrons listed include production oscillator tubes for airborne and missile use.

Write in No. 389 on Reader Service Card

POWER CONNECTORS — Miniature rectangular power connectors in a variety of contacts from 7 to 104 are described in an illustrated technical catalog prepared by **DeJur-Amsco Corp., Dept. S/A, 45 01 Northern Blvd., L. I. City 1, N. Y.** It includes specifications for the Series 250.

Write in No. 390 on Reader Service Card

SERVO ACTUATORS—Several models of linear hydraulic servo actuators are discussed in data sheets prepared by **Lear, Inc., Dept. S/A, 110 Ionia Ave., N. W., Grand Rapids 2, Mich.** The data sheet series include 119-2, 119-3, 119 4, and 119-5.

Write in No. 391 on Reader Service Card

PRECISION SWITCHES—Snap-acting precision switches are discussed in catalog 359 by **W. L. Maxson Corp., Unimax Switch Div., Dept. S/A, Ives Road, Wallingford, Conn.** Data on sealed switches for severe environments are given.

Write in No. 392 on Reader Service Card

ALUMINUM—A handy size, ready-reference handbook on machining of aluminum has been published by **Reynolds Metals Co., Dept. S/A, Richmond 18, Virginia.** Turning, milling, shaping and planing, drilling, reaming, tapping, filing and sawing, eight major machining operations are covered in the text and illustrations.

Write in No. 393 on Reader Service Card

MAGNESIUM ALLOYS—Physical and mechanical properties of magnesium castings, sheet and extrusions for airframe design are dealt with in a brochure by **Dow Chemical Co., Dept. S/A, Midland, Mich.** Case histories cover applications in aircraft, missiles and helicopters.

Write in No. 394 on Reader Service Card

CRYOGENERATORS — A folder on cryogenerators, for gas liquefaction systems, has been issued by **North American Philips Co., Cryogenics Div., Dept. S/A, 100 Stevens Ave., Mount Vernon, N. Y.** Curves are presented for each model showing the relationship between refrigeration capacity, condensing temperature and brake horsepower. Drawings of physical dimension, and operating principle and applications are included.

Write in No. 395 on Reader Service Card

more on page 308

YOU GIVE YOUR DESIGN A LONGER LIFE WHEN YOUR "SPECS" READ HYATT

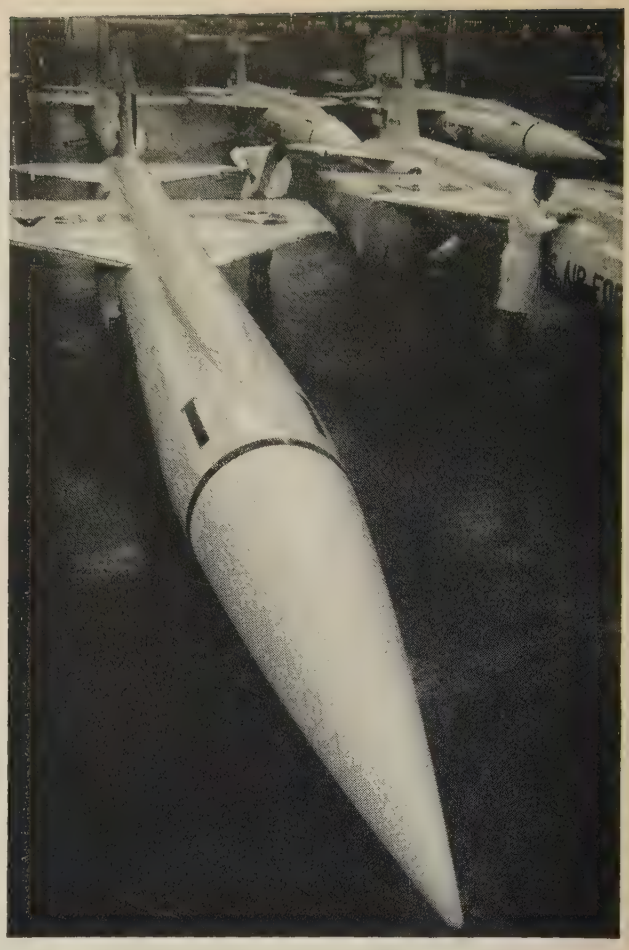
If you want smooth, trouble-free operation for the life of your design, you can have it with Hyatt! For Hyatt's built-in quality is electronically controlled to insure that the last Hyatt Hy-Roll bearing is just as accurate as the first. Hyatt reliability costs no more so why not have the best? Hyatt Bearings Division, General Motors Corporation, Harrison, N. J.

HYATT HY-ROLL BEARINGS

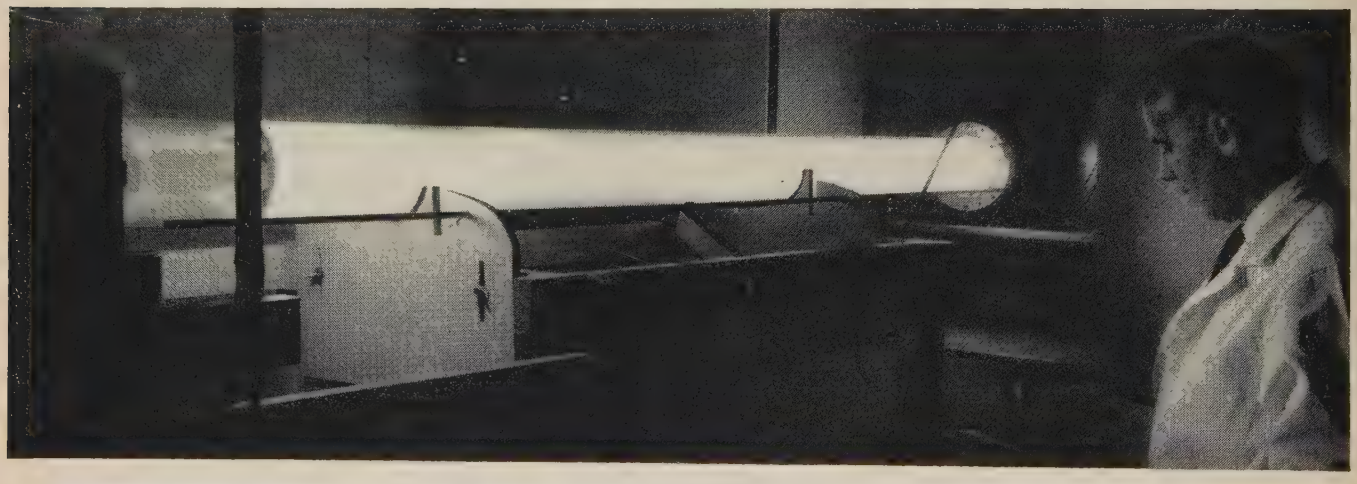
IN ROLLER BEARINGS HYATT IS THE WORD FOR GM RELIABILITY

Write in No. 233 on Reader Service Card at start of Product Preview Section

COUNTER-MOON. Drawing of an orbital vehicle designed by Boeing engineers and scientists for future space research. Manned vehicle, carrying advanced instruments, would orbit in moon's path but maintain position on opposite side of the earth from the moon. Space-age research studies underway at Boeing include other advanced orbital, lunar and interplanetary systems.



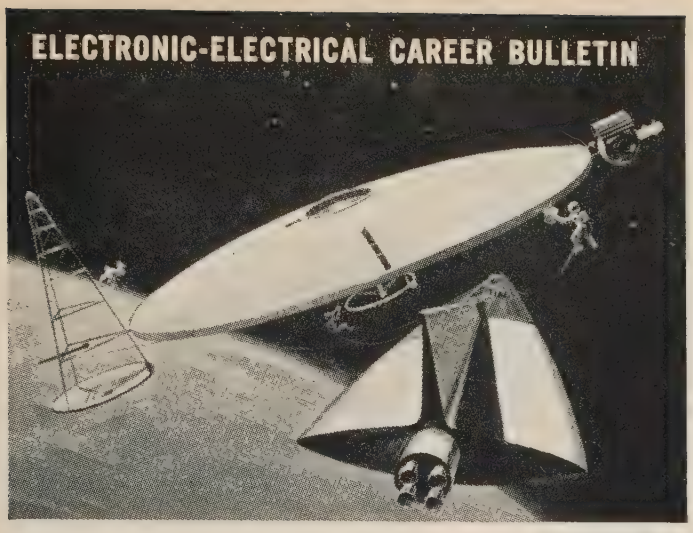
AIR DEFENSE MISSILES. Supersonic BOMARC missiles being readied for checkout in Boeing plant. In production for Air Defense Command, BOMARCS are nation's longest-range defense missiles and are designed to defend large areas against attacking aircraft. Advanced "B" model, now undergoing flight tests at Cape Canaveral, is designed for a range of more than 400 miles.



SHOCK TUBE. Industry's most powerful shock tube, designed and built by Boeing scientists for electromagnetic radiation research using gases at very high temperatures. Related research at Boeing includes extra-terrestrial gases and space gas-system structures. Goal of scientists of the Boeing Scientific Research Laboratories is to develop new and fundamental knowledge at the frontiers of science.

JET STARTER. Boeing 502 gas turbine-driven compressor, mounted in Turbo-Starter truck, gives fast, sure starts to jet and turbo-prop engines. Boeing Turbo-Starters have been ordered by major U.S., Canadian and European airlines. Boeing 502 gas turbines also power minesweeping launches, the first turbine craft to enter fleet service overseas with the U.S. Navy.

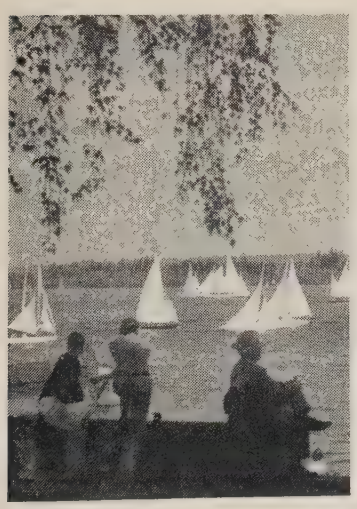
BOEING



MARS VEHICLE. Drawing, based on Boeing study, of space vehicle designed for launching from orbiting platform for reconnaissance flight to Mars and return. Lunar, orbital and interplanetary system studies, and expanding programs such as the advanced Minuteman solid-propellant ICBM, are typical of challenging, long-range assignments Boeing offers electronic-electrical engineers.

DARK TUNNEL. View in 100-foot dark tunnel, part of extensive Boeing infrared research and development facilities. Boeing investigations include use of infrared, visible and ultra-violet techniques for use in communication, navigation, detection and guidance at altitudes above tropopause. IR systems, inertial navigation, electrical power systems for satellites, shockwave radiation and refraction and irdome heating are other areas of assignments open at Boeing.

ANTENNA PATTERN RANGE, with movable towers capable of handling models up to 1000 pounds. Boeing has openings in ECM antenna development, and in gas, solid and liquid dielectric research, as well as large-aperture antennas for ASMs, orbital vehicles and airborne warning systems. Other openings are available in instrumentation, missile guidance and control.



SEATTLE area, boating capital of U.S., offers world-famous recreational facilities. Fresh and salt water boating and fishing are only one hour from dramatic snow-capped mountains renowned for six-months-a-year skiing. Mild year-round climate. Excellent schools and universities, cultural activities, modern housing and shopping centers. Wonderful Western living for the whole family!

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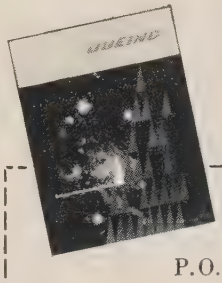

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Boeing Airplane Company,
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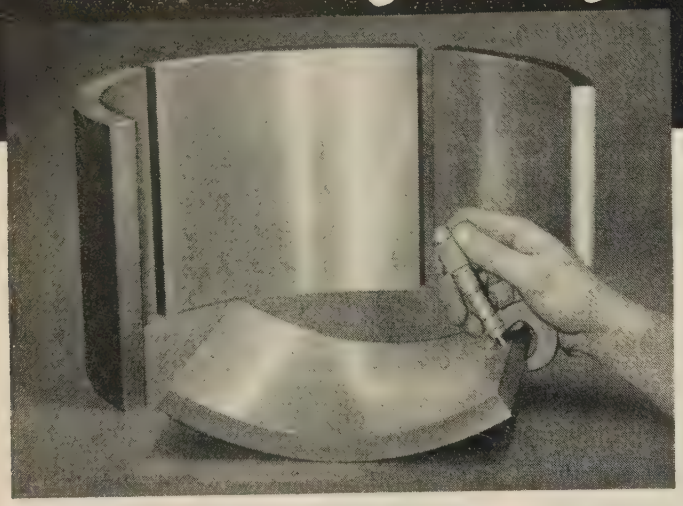
How Fansteel 77 Metal PLUS Fansteel Engineering



added up to a $10,000 Saving!

Fansteel does more than just talk "customer savings." Take the case of these Fansteel 77 Metal contour parts, ¾" thick x 9½" high x 15" developed length with a radius of 9".

NEED A METAL 50% HEAVIER THAN LEAD?

Fansteel 77 is a metal produced especially for applications requiring maximum density in limited space. It is twice as heavy as steel, 50% heavier than lead, yet—much stronger than cast iron. Non-magnetic 77 Metal is easily machined and easily joined to other metals. Furthermore, it is **non-toxic** and **non-radioactive** requiring no special precautions in handling. Available in finished or semi-finished parts to your specifications or in bars, rods, rings, disks, special shapes.

Fansteel engineers developed new fabrication techniques which cut the cost 30% over former methods of producing the part. To the customer this added up to a $10,000 saving on this one order alone.

It's just one more example of how the constant search by Fansteel engineers for cost-cutting ways of fabricating Fansteel metals, pays off in big savings for the customer.

Investigate the possibilities of similar savings on your parts... whether it's made from 77 metal, tantalum, molybdenum, columbium or tungsten. Call in the Fansteel man.

K598A

FANSTEEL

Fansteel Metallurgical Corporation
North Chicago, Illinois,
U.S.A.

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CONNECTORS—Its electrical connector facilities and techniques that have led to developments such as the miniature quick-disconnect line and snap-in connectors have been briefly described in eight-page Brochure DE-28 by **The Deutsch Co., Dept. S/A, 7000 Avalon Blvd., Los Angeles, Calif.** The connectors are used in high-speed aircraft and missiles.

Write in No. 396 on Reader Service Card

POWER AMPLIFIER—A compact, manually tuned, dual channel, 2.5-kw power amplifier, the 204F-1, has been described in a six-page folder available from **Collins Radio Co., Dept. S/A, Cedar Rapids, Ia.** The HF SSB linear power amplifier uses ceramic-seal tetrodes.

Write in No. 397 on Reader Service Card

SELECTOR SWITCHES—A catalog illustrating and describing rotary selector switches with wafers which lift out instantly has been issued by **Chicago Dynamic Industries, Inc., Precision Products Div., Dept S/A, 1725 Diversey Blvd., Chicago 14, Ill.** It gives dimensional drawings and describes different size switches, giving technical details on construction, wafers, receptacles, mounting, position, decks, operation and special variations.

Write in No. 398 on Reader Service Card

FILTER ASSEMBLIES—A 6 page catalog. #BFD-64, describing 5 standardized lines of high and low pressure T-type in-line filter assemblies, replacement filter elements, dual bowl filters, and differential pressure indicator filter assemblies has been issued by **Bendix Aviation Corp., Filter Div., Dept. S/A, 434 W. Twelve Mile Rd., Madison Heights, Mich.** It illustrates filter assemblies and replacement elements with photographs and dimensional line drawings.

Write in No. 399 on Reader Service Card

AIRBORNE POWER SUPFLY—A 4-page, 2-color brochure describing the specifications, operational characteristics, and design features of airborne strain gage power supplies has been issued by **Neff Instrument Corp., Dept. S/A, 2211 E. Foothill Blvd., Pasadena, Calif.** Graphs illustrate load regulation, temperature stability, and line regulation.

Write in No. 400 on Reader Service Card

SERVO ACTUATORS—Electrohydraulic servo actuators, custom-designed integrated packages are described in catalog 170 by **Moog Servocontrols, Inc., Dept. S/A, Proner Airport, E. Aurora, N. Y.** Typical applications in aircraft, missiles and rockets as well as critical industrial systems are discussed.

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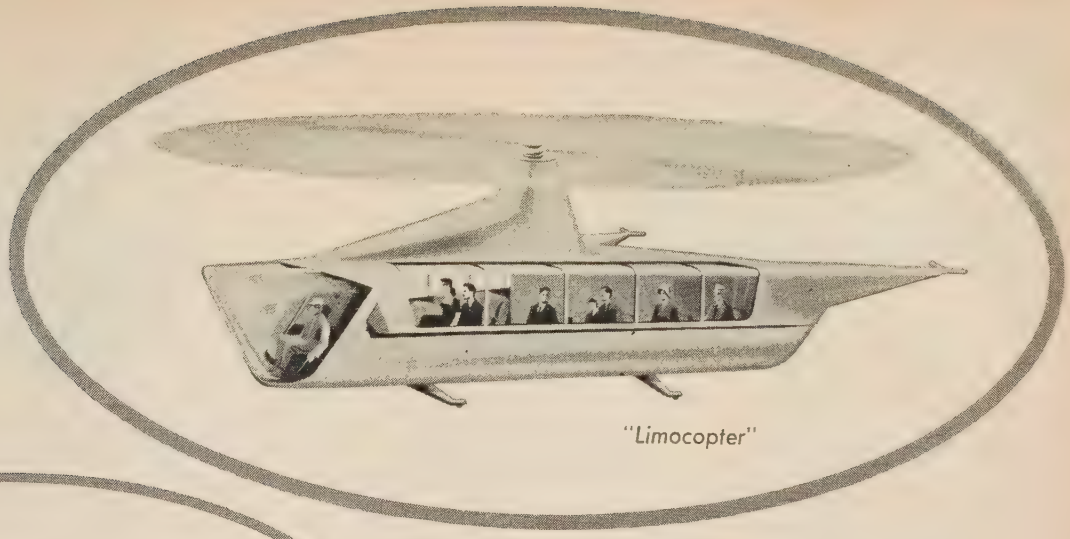
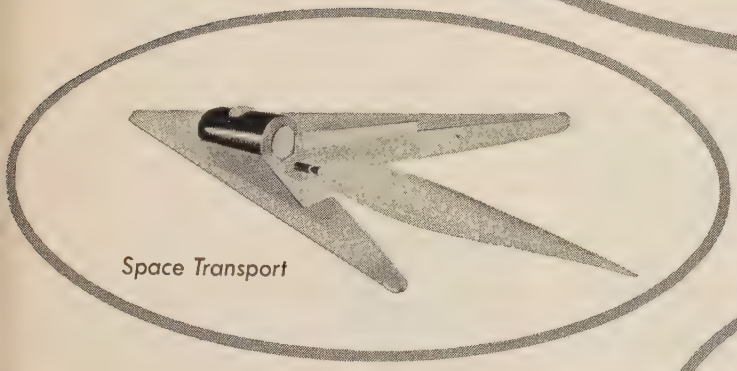
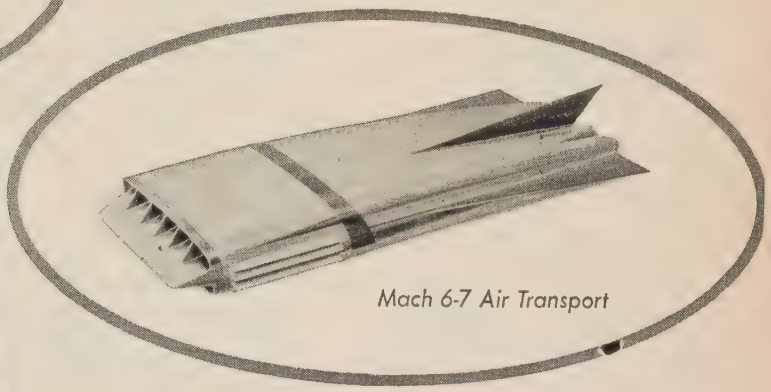
more on page 310



"Limocopter"



Space Transport



Mach 6-7 Air Transport

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Bold plans revealed in Lockheed's program of total flight technology

Air/Space travel, whether the vehicle is manned or unmanned, poses vast problems. To expand the total technology of flight, Lockheed's California Division proposes bold new concepts for both military and commercial vehicles. In line with this, the Company has assumed major responsibility for Research and Development on future space vehicles. This responsibility extends from development of advanced components to major complex systems.

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This markedly expanded program into the total concept of flight creates urgent need for personnel with high-level skills. The concept ranges from subsonic to hypersonic speeds; from atmospheric to outer space vehicles.

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Immediate openings are available in: Aerothermodynamics; propulsion; armament; electronics – research, systems, packaging; servomechanisms – flight controls; sound and vibration; operations research; physics – infrared, acoustics, electro-physical; antenna and telemetry; and underwater sound propagation.

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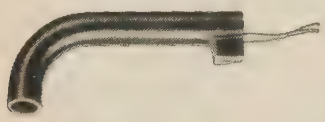
LOCKHEED / CALIFORNIA DIVISION

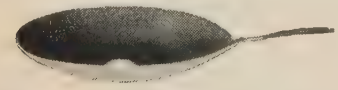
Check Employment Inquiry Form on Page 195

CHROMALOX
FLEXIBLE AND MOLDED ELECTRIC HEATERS

Electronic heating harness molded to fit small object. Three woven heaters molded in high temperature refractory and aluminum case (left) and glass and polyester resin (center and right). Small thermostat is molded to base of center heater.



Neoprene rubber molded heater, eliminates ice clogging of aircraft pitot tube.



Silicone rubber laminated heater molded on a 2⅛" spherical radius. Two of these completely cover and protect guided missile storage battery reservoir.

Silicone rubber laminated heater bonded to a metal component for an aeronautical camera.

Neoprene rubber laminated battery heater.

Woven heaters. Temperatures to 800°F. Any size or shape up to 24" wide and to any length. Can be supplied with eyelets, snap fasteners, mounting holes. Moisture and abrasion resistance can be provided by silicone rubber coating.

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DATA PREVIEW

CHROMIUM — A chromium metal, called "Iochrome" is described in a bulletin by **Chromalloy Corp., Dept. S/A, 450 Tarrytown Rd., White Plains, N. Y.** It includes suggested applications.

Write in No. 402 on Reader Service Card

HYDRAULIC ACTUATORS — Rotary power hydraulic actuators are covered in data sheet #592 prepared by **Vard, Inc., Dept. S/A, 2981 E. Colorado St., Pasedena, Calif.** It contains technical information and typical applications, photographs of component parts, and specification charts.

Write in No. 403 on Reader Service Card

FASTENER ENGAGEMENTS — The drawbacks of long threaded fastener engagements have been briefly discussed in a four-page bulletin issued by **Standard Pressed Steel Co., Dept. S/A, Jenkintown, Pa.** The Bulletin, "Lead Deviation As It Applies to Long Thread Engagement," charts the effect of engagement length on screw thread pitch diameter tolerance.

Write in No. 404 on Reader Service Card

DATA HANDLING—A complete range of precision electronic measuring and data handling systems has been outlined in Bulletin G-101 by **Gilmore Industries, Inc., Dept. S/A, 13015 Woodland Ave., Cleveland 20, O.** The systems measure weight, strain, force and thrust, flow, pressure, and temperature in the aircraft, missile and other industries.

Write in No. 455 on Reader Service Card

INVERTER—A data sheet giving detailed technical data on a transistorized regulated power inverter has been prepared by **Arnold Magnetics Corp., Dept. S/A, 4613 S. Jefferson Blvd., Los Angeles 16, Calif.** It includes description of a short circuit and input over-voltage protection feature.

Write in No. 405 on Reader Service Card

JUNCTION—Data Sheet TA-11 on the TA-11 thermoelectric junction for cooling, heating, power generation and dynamic heat transfer has been issued by **Ohio Semiconductors, Inc., Dept. S/A, 1035 W. Third Ave., Columbus 8, O.** The semiconductor unit features rugged construction and very low contact resistance.

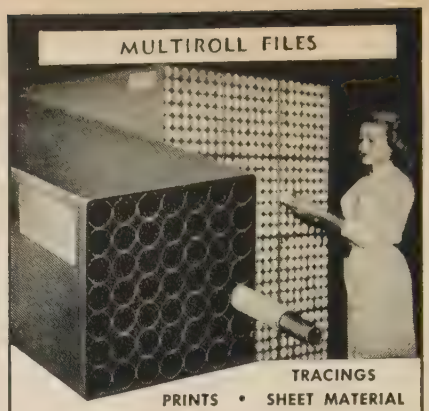
Write in No. 406 on Reader Service Card

SYNCHRO DIFFERENTIAL—A size 8 synchro differential line is described in data sheet 801-D4 issued by **Daystrom, Inc., Transicoil Div., Dept. S/A, Worcester Pa.** It includes dimensioned and schematic drawings, photos, and tales of electrical specifications.

Write in No. 407 on Reader Service Card

more on page 312

MULTIROLL FILES



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49 Tube 1¾" I.D. MODEL	49AB $7.50	49CD $9.50	4930 $12.80	4936 $13.80	4942 $14.80
25 Tube 2¼" I.D.	25AB $7.00	25CD $9.00	2530 $11.80	2536 $12.80	2542 $13.80

Shipping Weight

Model 49	8 lbs.	12 lbs.	15 lbs.	18 lbs.	20 lbs.
Model 25	6 lbs.	10 lbs.	13 lbs.	15 lbs.	17 lbs.

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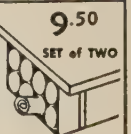
Designed to Mount Under Board—Mounting Brackets Furnished. Gray Only.



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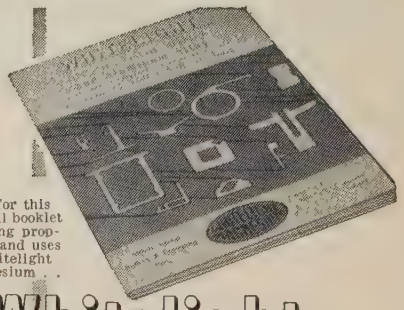

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AZ61
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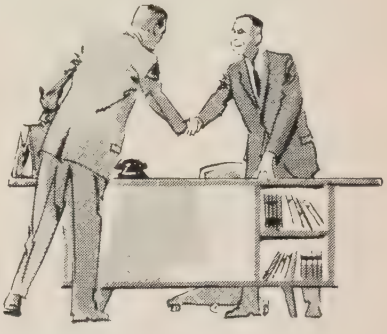
A letter, wire or phone call will bring our representatives to your office with complete facts about E-P associate-contracting capabilities.



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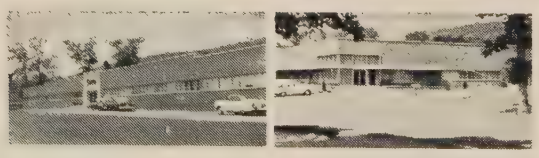
- Environmental Testing



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J. R. CLOVIS, Personnel Department SA-12

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U.S. HIGHWAY 22, PLAINFIELD, NEW JERSEY PLAINFIELD 7-1600

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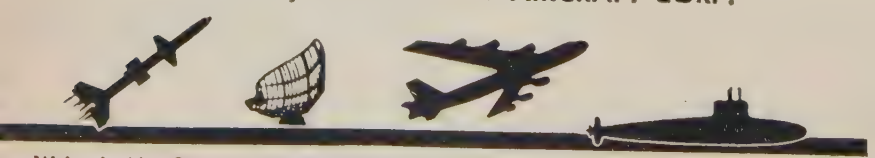
A Subsidiary of LOCKHEED AIRCRAFT CORP.



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SPRING STEEL—Catalog 579, a 28-page publication, offers physical data on cold-rolled, high-carbon flat spring steels made by **Athenia Steel Div., National-Standard Co., Dept. S/A, Clifton, N. J.** A conversion chart shows the relationships between Rockwell, Rockwell Superficial, Tukon and other testers.

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EXPANSION JOINTS — A complete line of pressure-balanced expansion joints for absorbing pipeline movement without imposing pressure thrust is discussed by **Zallea Bros., Dept. S/A, 815 Locust St., Wilmington 99, Del.** They have application in missile and jet engine propulsion test facilities, chemical plants, paper mills, steel mills, refineries, oil and gas lines, power plants, steam lines, water works, gas works and wind tunnels.

Write in No. 409 on Reader Service Card

CLAMPS—Catalog 50, said to be the only complete listing in the industry devoted to miniature clamping devices has been issued by **Sterling Precision Corp., Dept. S/A, 17 Matinecock Ave., Port Washington, N.Y.** The booklet includes data on clamps for surface mounting motors, potentiometers, synchros, and other devices.

Write in No. 410 on Reader Service Card

SEMICONDUCTORS — TE-1340A, a condensed catalog listing all basic silicon and germanium products made by **Transitron Electronic Corp., Dept. S/A, 168-182 Albion St., Wakefield, Mass.** Package photographs of the components, data charts, and a brief description of the transistors, diodes, capacitors and regulators are included.

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WELD SHAVER—Operating features of a weld shaver capable of cutting and finishing weld beads to within +.000 to +.001 in. of surface plane have been presented in Catalog 17, issued by **Zephyr Mfg. Co., Inc., Dept. S/A, 201 Hindry Ave., Inglewood, Calif.** Included are models for finishing aluminum and other soft alloy weldments, as well as titanium, stainless steel, and hard alloy weld beads.

Write in No. 412 on Reader Service Card

TRANSISTORS—Typical operation and maximum ratings of all Bendix production transistors are listed in the recently revised Transistor Chart, available from **Red Bank Div., Bendix Aviation Corp., Dept. S/A, 201 Westwood Ave., Long Branch, N.J.** Typical application information for the germanium PNP transistors is included.

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more on page 314

Easy-to-form metals with high strength up to 1000 F

AM 350 and AM 355, precipitation hardening stainless steels by Allegheny Ludlum have many advantages for designers of missiles and supersonic aircraft in solving space age problems.

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AM 350 is available commercially in sheet, strip, foil, small bars and wire. AM 355, best suited for heavier sections, is available commercially in forgings, forging billets, plates, bars, wire, sheet and strip.

For further information, see your A-L sales engineer or write for the new technical booklet, "AM 350 and AM 355." **Allegheny Ludlum Steel Corporation, Oliver Building, Pittsburgh 22, Pa.**

863

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EVERY FORM OF STAINLESS . . . EVERY HELP IN USING IT

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Stalker **ORTHOBRAZE** is ideal for precision sheet metal assemblies — up to 48" in diameter. Stalker provides complete engineering and production facilities for the fabrication and high temperature brazing of stainless steel or super-alloy. U.S. Air Force certification.

THE STALKER CORPORATION
905 Woodside Avenue
Essexville, Michigan

Phone: Bay City —
TWinbrook 3-7562

Write in No. 243 on Reader Service Card at start of Product Preview Section

DATA PREVIEW

NICKEL TUBING—CM-359, a four-page folder on the chemical composition and properties of four types of nickel tubing, has been published by **Superior Tube Co., Dept. S/A, Norristown, Pa.** The folder describes small tubing made from "A" nickel, low carbon nickel, "D" nickel, and Duranickel.

Write in No. 414 on Reader Service Card

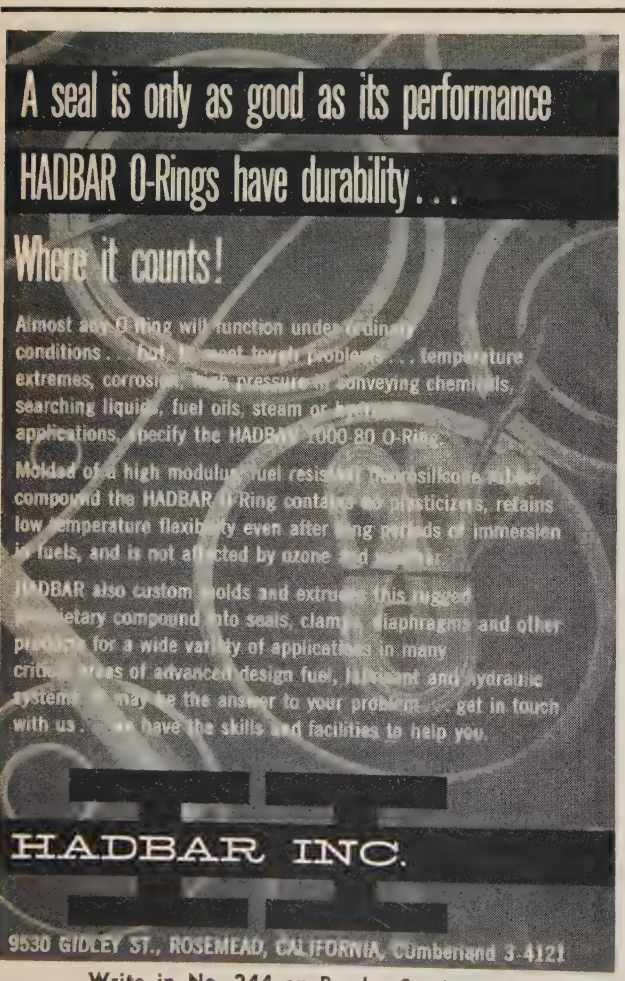
PRESSURE PICKUP — Type 4-313A pressure pickup is described in a 2 page bulletin by **Consolidated Electrodynamics, Dept. S/A, 360 Sierra Madre Villa, Pasadena, Calif.** Bulletin No. 1541 discusses absolute and gage models in pressure ranges from 100 to 5000 psi.

Write in No. 415 on Reader Service Card

PROPELLANT ACTUATION—Propellant-actuated devices for remote application of force to various mechanical needs in the missile field are covered in a series of sheets available from **Beckman & Whitley, Inc., Dept. S/A, San Carlos, Calif.** Among them is Form DIS 459 on electrical disconnects, and Form PAV-459 on normally closed valves: both devices are explosively operated.

Write in No. 416 on Reader Service Card

more on page 316


A seal is only as good as its performance
HADBAR O-Rings have durability...
Where it counts!
HADBAR INC.
9530 GIDLEY ST., ROSEMEAD, CALIFORNIA, Cumberland 3-4121

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Same formula as famous Kroil that has pleased 14,000 industrial users for 10 years or more.

Loosens stuck together metal parts, bushings, bearings, bolts, screws, pipe, etc., "anything from an embalmer's needle to a bulldozer," one customer said.

"Like an extra employee," said another. "Turned rust into mush, put $50,000 equipment back to work."

You too can get these results.

Try Aerokroil at our risk. Send $2 cash, and we'll pay postage.

KANO LABS. Nashville 11, Tenn. 1097 Trompson Lane

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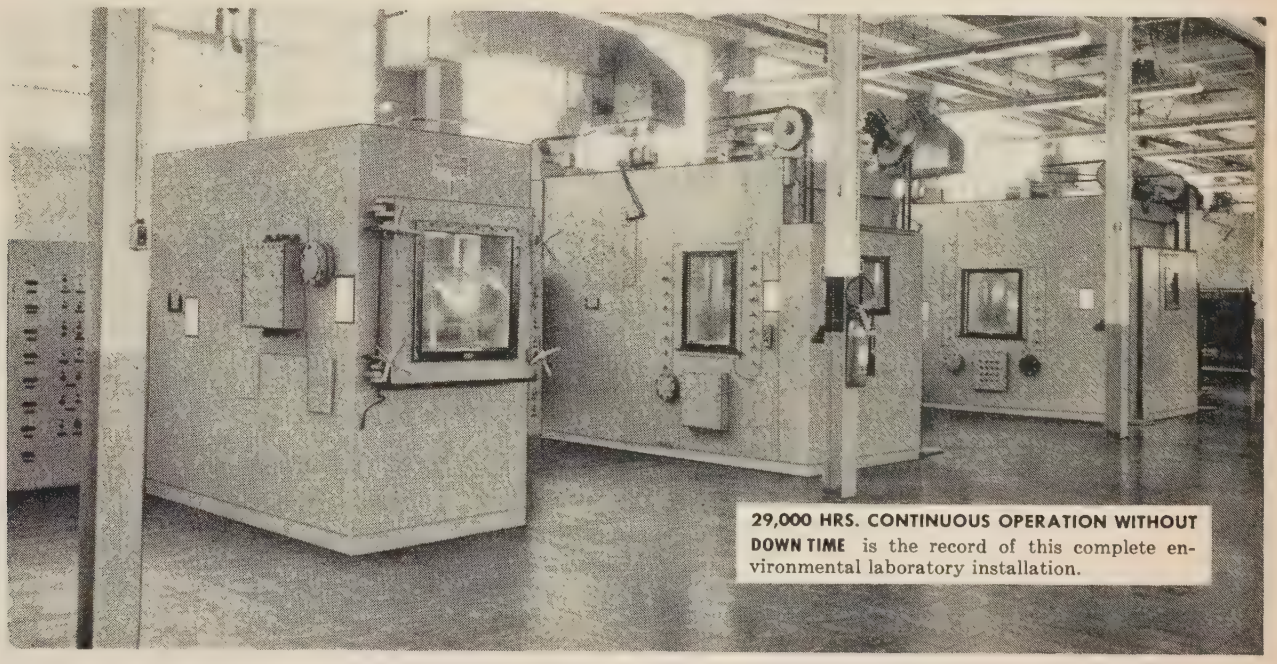
HOW GUARDITE CUTS COSTS OF ENVIRONMENTAL TESTING



29,000 HRS. CONTINUOUS OPERATION WITHOUT DOWN TIME is the record of this complete environmental laboratory installation.

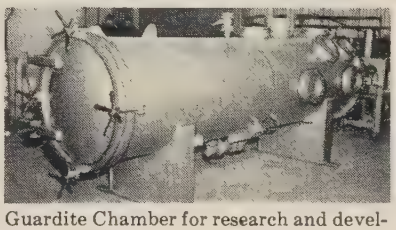
Superb Engineering, Precision Construction, Keep Maintenance Expense at Record Low

Too often the lowest bid ends up as the *highest overall cost*—when down time and excessive maintenance expense are added.

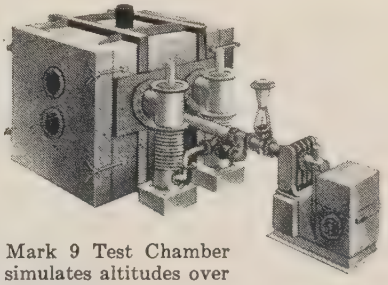
Guardite bids on Environmental Test Equipment are always sharp-pencilled—but never at the sacrifice of performance and durability. The most significant savings show up in trouble-free operation, year after year. Guardite's exceptional record of low maintenance and high performance applies to a very wide field of test equipment, from 3 cu. ft. chambers to huge installations that explore new frontiers of hyper-environmental research.

We are equipped to accept your toughest problems on a design-study basis—or we will do all engineering, fabricating and testing from your performance specifications. Write or phone for information—*and be sure to get the new Guardite Catalog.*

From 3 Cu. Ft. Chambers to Mammoth Testing Installations

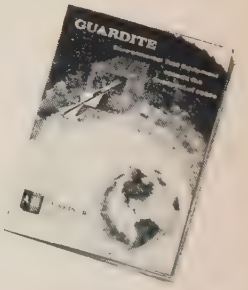


Guardite Chamber for research and development with special military equipment



Mark 9 Test Chamber simulates altitudes over 1,000,000 ft., temperatures —100°F to 1000°F.

High-Low Temperature Trop-Arctic Chamber —100°F to 250°F, 3 cu. ft. capacity (Available from stock)



Write for complete new catalog to Guardite Company, Dept. SA, Wheeling, Illinois

GUARDITE
DIVISION OF
AMERICAN-MARIETTA COMPANY

Write in No. 246 on Reader Service Card at start of Product Preview Section

ON MARK COUPLINGS

Eliminate Spillage Hazard with ON MARK Ground Service Pressure Re-Oil Couplings

Designed to satisfy the requirements of MIL-A-25676, and MIL-N-25677, On Mark's series 5-3002 Ground Service Pressure Re-Oil Couplings actually exceed the specifications in 4 important areas.

NO SPILLAGE, even when disconnected under line pressure. Keeps area clean, free from hazard of dripping oil.

EASY CONNECT AND DISCONNECT with one simple motion of pushing the mating parts together. No turning of parts or holding back the actuating ring is necessary.

NO AIR INCLUSION on connection.

Airborne adapter may be subjected to **TEMPERATURES UP TO 500° F.**

On Mark Re-Oil Couplings are used for ground service applications on systems with operating pressures up to 1000 PSI. Currently available in ½" and ¾" line sizes.

For full information please contact

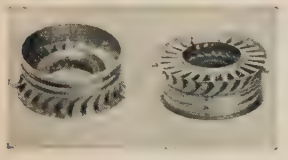
ON MARK COUPLINGS, INC.

4440 York Boulevard, Los Angeles 41, California

Telephone CLinton 4-2278

Representatives: Airsupply Company, Beverly Hills, Calif.; Aero Engineering Company, Mineola, Long Island, N.Y. — Divisions of The Garrett Corporation

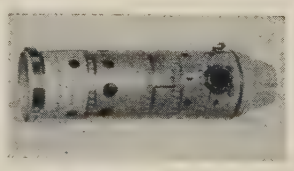
Write in No. 247 on Reader Service Card at start of Product Preview Section

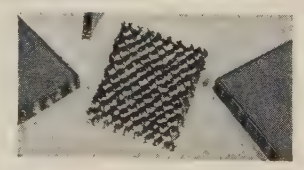


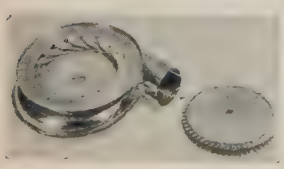
We Furnace Braze Stainless Alloys

To eliminate problems of distortion, stress, oxidation, and porous welds

The advantages of stainless alloy brazing in dry hydrogen or vacuum environment furnaces are many. And the use of brazing for high-temperature service parts is growing just as fast as potential users learn to design for it. We offer technical design assistance to further the acceptance of this modern joining technique. Ten years of pioneering this field, plus operating three stainless processing plants, plus manufacturing our own Nicrobraz® brazing alloys, fully qualifies us to give initial guidance to your design crew in planning brazed stainless components. Call TWinbrook 3-3800 in Detroit, or write to find out how we might help you.







STAINLESS PROCESSING DIVISION

WALL COLMONOY CORPORATION

19345 John R Street • Detroit 3, Michigan

There are Wall Colmonoy furnace plants in Detroit, Michigan; Morrisville, Pennsylvania; and Montebello, California

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COMPUTER — Bulletin AB-059 is a six-page illustrated publication on the G-15 digital computer made by **Bendix Computer Div., Dept. S/A, 5630 Arbor Vitae St., Los Angeles 45, Calif.** Special emphasis has been given the unit's magazine-loaded photo tape reader and descriptions are included for programing systems, and accessory punched card, magnetic tape and paper tape equipment.

Write in No. 417 on Reader Service Card

COMPASS SYSTEM — A lightweight, simplified compass system equally suitable for commercial and executive aircraft has been described in Publication 569-28 by **Eclipse-Pioneer Div., Bendix Aviation Corp., Dept. S/A, Teterboro, N.J.** The Continental System is recommended for operation between latitudes 65 deg N and 65 deg S.

Write in No. 418 on Reader Service Card

TUBES — The principal specifications of 55 JEDEC registered cathode-ray tubes for original equipment are presented in a short-form catalog issued by **Electronic Tube Div., Allen B. Du Mont Laboratories, Inc., Dept. S/A, 750 Bloomfield Ave., Clifton, N.J.** The six-page foldout form, suitable for ring-binder filing, offers physical characteristics, electrical ratings, and typical operating conditions.

Write in No. 419 on Reader Service Card

PULSE INSTRUMENTATION — A 48-page, 1959-1960 General Catalog, which includes complete technical data on a broad range of pulse instrumentation, has been prepared by **Electro-Pulse, Inc., Dept. S/A, 11861 Teale St., Culver City, Calif.** The publication covers pulse, word and time generators, and electronic counters, and choice and use information is contained in detailed technical articles.

Write in No. 420 on Reader Service Card

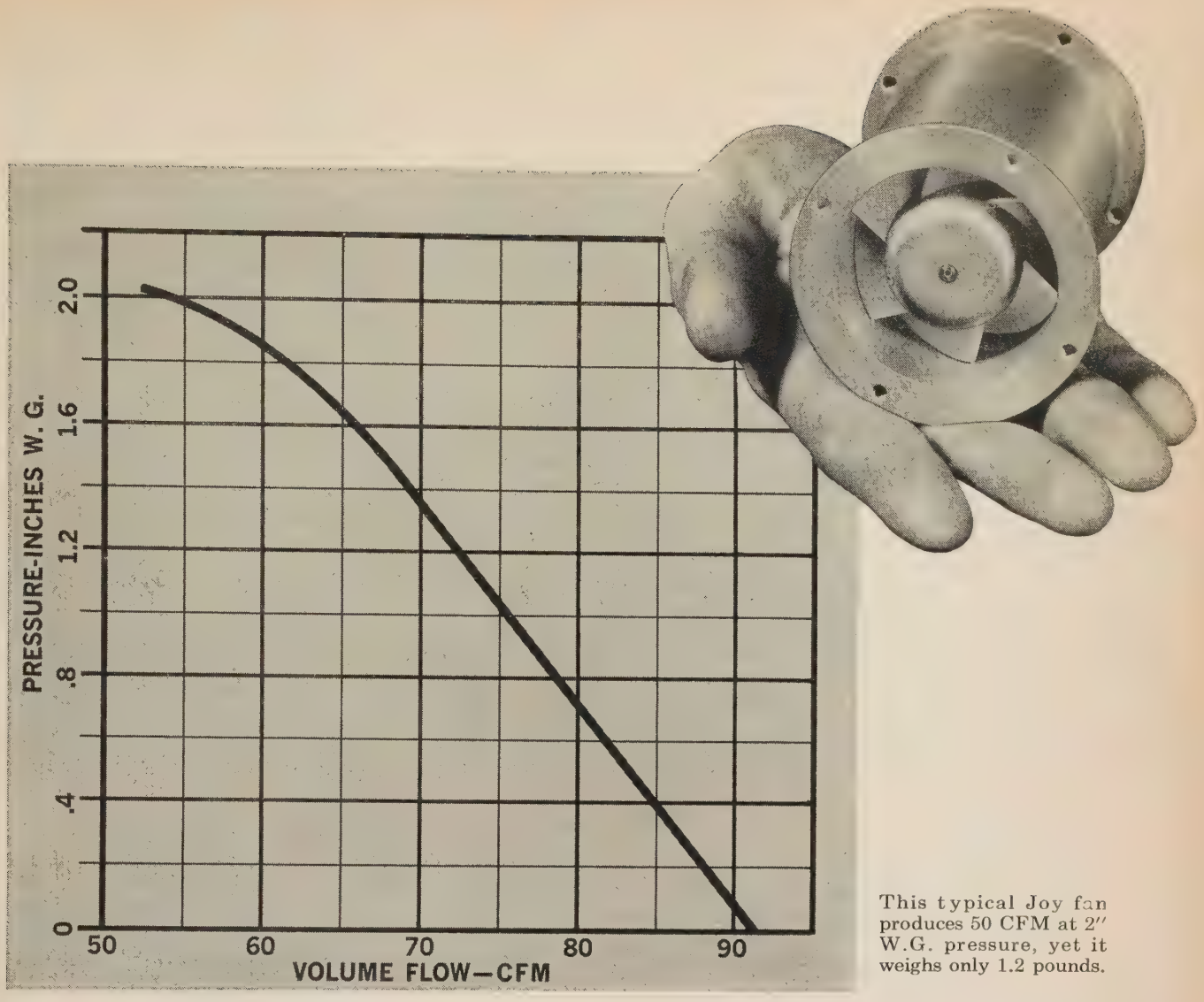
CENTRIFUGE—A centrifuge for testing aircraft and missile components under positive and negative g-effects and high ramp functions is available from **Genisco, Inc., Dept. S/A, 2233 Federal Ave., Los Angeles 64, Calif.** Specifications are for the model A902 centrifuge.

Write in No. 421 on Reader Service Card

SEALED RELAYS—Information on hermetically sealed microminiature, sub-miniature miniature, and high speed relays for military and general purpose applications is contained in bulletin GEA-6628 issued by **General Electric Co., Dept. S/A, Schenectady 5, N.Y.** It contains photographs, circuit diagrams coil data, and specifications.

Write in No. 422 on Reader Service Card

more on page 318



This typical Joy fan produces 50 CFM at 2" W.G. pressure, yet it weighs only 1.2 pounds.

➔ *Joy Design Means:*

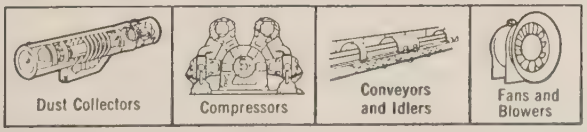
HIGHEST OUTPUT PER POUND OF FAN

Joy aircraft and electric fans are designed to provide maximum CFM per pound of fan. The inherent high efficiency of the basic vaneaxial design, with the motor mounted inside the fan, has made Joy fans standard wherever weight or size is a critical consideration.

Joy fans meet Mil Specs, and have been accepted for both airborne and ground installations. RCA, Boeing, Douglas, Goodyear, Motorola, Lockheed, and Raytheon are just a few of the firms incorporating Joy fans in their products.

Over 340 standard models are available, and custom design can be supplied to meet your special requirements. For complete information on how compact, efficient Joy fans can solve your design problems, write for Bulletin 924-38.

AIR MOVING EQUIPMENT FOR ALL INDUSTRY



JOY

Joy Manufacturing Company
Oliver Building, Pittsburgh 22, Pa.

In Canada: Joy Manufacturing Company (Canada) Limited, Galt, Ontario

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New Technical Data
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CENTRAL COMPRESSION SYSTEMS

New data book and catalog belongs in your files . . . when you are planning, designing or specifying high pressure air and gas facilities. Includes description and engineering data sheets on new or improved CARDAIR (formerly Cardox) Central Compression Systems—now used by prime contractors, suppliers of missile components and controls, testing laboratories . . . wherever high pressure —100° F. dew point (less than 4 ppm oil content) air, helium or nitrogen is required.

Systems are designed for any degree of purification. Wide range of models, skid-based fixed or mobile,—pressure ranges from 4,000 to 12,000 psi—50 to 150 SCFM. Completely engineered systems or package units. Backed by 15 years' successful performance in high pressure (12,000 psi) gases, including Mil Specs. District offices and warehouses throughout country. Mail coupon today.

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High Pressure Pneumatics Division
307 N. Michigan Ave., Chicago 1, Ill.
Please send new catalog and data file on CARDAIR Central Compression Systems.

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City_____ Zone___ State_____

Western States Distributor:
General Air Equipment
824 Hollywood Way, Burbank, Cal.

Write in No. 250 on Reader Service Card

DATA PREVIEW

METAL POWDERS—A brochure lists the types of prealloyed metal powders, showing properties of sintered Vasco steel powders, and has been prepared by **Vanadium-Alloys Steel Co., Dept. S/A, Latrobe, Pa.** It shows photographs of parts fabricated from prealloyed metal powders and offers tool recommendations.

Write in No. 423 on Reader Service Card

METAL COATING—A brochure describing the flame ceramic process of protecting metals against temperatures up to 5500° F, has been issued by **Continental Coatings Corp., Dept. S/A, 17706 Miles Ave., Cleveland 28, Ohio.** It also covers the origins and actual and potential applications.

Write in No. 424 on Reader Service Card

DELAY LINES—Delay-line techniques that result in higher storage capacity in smaller units, longer time delays, and delay lines with polarity sensitivity are discussed in Bulletins 201, 202 and 203 by **Deltime, Inc., Dept. S/A, 608 Fayette Ave., Mamaroneck, N.Y.** Other advances and refinements covered include servo-operated delay lines and high signal-to-noise ratio delay lines.

Write in No. 425 on Reader Service Card

SHOCK TESTER—Features and operation of the HY-6500 shock tester for production applications have been described in Bulletin 4-71 by **Consolidated Electrodynamics Corp., Dept. S/A, 1775 Mt. Read Blvd., Rochester 3, N.Y.** The tester can produce, in rapid succession, either half-sine pulses or sawtooth pulses, and it will accept large bulky specimens as well as small components.

Write in No. 426 on Reader Service Card

POTENTIOMETERS—Complete specification sheets for standard wire wound single- and multi-turn precision potentiometers are included in the comprehensive Catalog 202, issued by **Spectrol Electronics Corp., Dept. S/A, 1704 S. Del Mar Ave., San Gabriel, Calif.** Company capabilities for the design of special potentiometers and precision mechanisms are also covered in the 100-page publication.

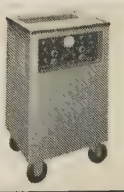
Write in No. 427 on Reader Service Card

DRILLING — Catalog SP-165, a 24-page booklet describing a revolutionary new spiral point geometry for converting standard twist drills into precision tools, has been published by **Cincinnati Lathe and Tool Co., Dept. S/A, Cincinnati 9, O.** The publication covers cost-reducing advantages of the point and shows operation of the Spiropoint drill sharpening machine for producing the new geometry.

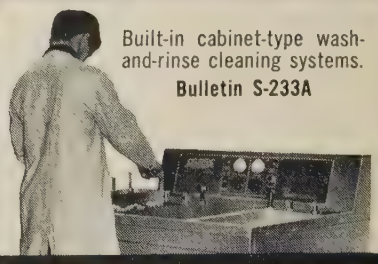
Write in No. 428 on Reader Service Card

more on page 320

Cleaning Problem?
SONOGEN®
Ultrasonic Cleaners by
BRANSON
may be your answer!



½-gallon and larger benchtop models, and (illustrated) 5- and 12-gallon self-contained rollaround units.
Bulletin S-509, S-217B



Built-in cabinet-type wash-and-rinse cleaning systems.
Bulletin S-233A

Modular cabinet-type systems with Cleaning, Filter / Heater / Recirculator, Rinsing, and Drying units.
Bulletin S-236

Custom-engineered cleaning installations: for batch and conveyorized cleaning, and for continuous-flow cleaning in strip and wire mills.
Bulletin S-235

Branson offers experienced counsel in adapting the flexibility of SONOGEN® Ultrasonic Cleaning Equipment to **your** needs. Tell us the problem, and we'll follow through from planning and installation to maintenance, with factory-trained specialists available nationwide.

Send Coupon to **BRANSON ULTRASONIC CORPORATION**
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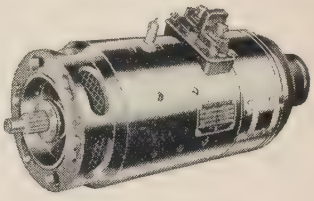
Write in No. 251 on Reader Service Card

Lockheed picks J&H system for JetStar

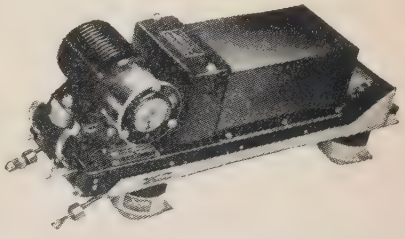
Diverse requirements of corporate and military flying in an economy-sized jet transport are brilliantly met by Lockheed's JetStar, powered by four Pratt & Whitney JT-12 engines.

For the engine-starting and electric power needs of the JetStar, Lockheed selected a starter-generator system by J&H. This system is self-contained and automatically performs all engine-starting functions except "ignition on" and "fuel on." It also provides all power-generating control and protective functions at the extreme altitude and temperature environments of the JetStar.

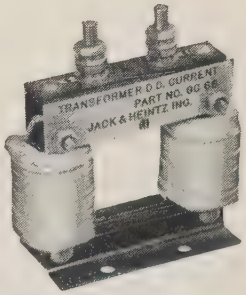
Jack & Heintz can meet your electric system needs with equal compactness, simplicity, reliability and low weight. Starter-generator systems available from J&H include manual, semiautomatic and completely automatic for the entire spectrum of turbojet, turboprop and turboshaft engines. The systems are particularly adaptable to the new, smaller jet engines rated to 4000-lb. thrust. Write to Jack & Heintz, Inc., 17634 Broadway, Cleveland 1, Ohio.



23035 STARTER-GENERATOR: engine-driven; air-blast-cooled; for use as engine-starter and as 28-v d-c power source.



GC18 CONTROL PANEL: for use with 200-400 amp, 30-v d-c starter-generators; includes fault detection, protective and regulating components necessary on single or multi-generator systems.



GC66 CURRENT TRANSFORMERS: for generator and feeder fault detection; transformer scheme has proved superior to conventional shunt-detection method.

JACK & HEINTZ, Inc.

SYSTEMS FOR AIRCRAFT, MISSILES AND GROUND SUPPORT

Write in No. 252 on Reader Service Card at start of Product Preview Section

The engineer moves ahead as Vought forms 5 divisions

Advantages of divisionalization will be felt up and down the Chance Vought roster. And the engineer — mining new knowledge in five broad areas — is benefiting particularly. New, self-managing divisions give the professional man the career stability that comes from a balanced, integrated program. And, from among these divisions' many technical specialty areas, the engineer can find the position that most ideally fits his talents.

AERONAUTICS DIVISION Developing new generations of manned aircraft, atmospheric missiles, antisubmarine apparatus. Current work includes Navy-sponsored studies in submarine detection and classification; production of three versions of F8U *Crusader* aircraft.

ASTRONAUTICS DIVISION Concentrating on advanced vehicles for space exploration and on ballistic and anti-ballistic missile systems. Supplying four-stage *Scout* research rockets and launchers to NASA. Participation in the competition for the development of the *Dyna-Soar* boost-glide vehicle.

ELECTRONICS DIVISION Developing, manufacturing, marketing military systems including antennas and related electronics, ground support electronics, and antisubmarine apparatus.

RANGE SYSTEMS DIVISION Establishing and operating test ranges and test equipment for missiles and space vehicles. Twelve years' experience in remote base operation.

RESEARCH DIVISION Looking forward to a new Research Center. Basic research into astronautics, undersea warfare, the life sciences (relating to the human factors of flight), electrogravities and other areas.

One Vought division may well stand out today as a place for your most rapid advancement. Why not write for further information?

Professional Placement Office
Dept. O-12

CHANCE VOUGHT
DALLAS, TEXAS

Check Employment Inquiry Form on Page 195

DATA PREVIEW

METAL WORKING — Metal-working equipment for heat treating, welding, machining, stamping, and metal-forming for products from tiny bearing housings through heavy duty truck frames are described in a booklet by **Dana Corp., Parish Pressed Steel Div., Dept. S/A, Reading, Pa.**

Write in No. 429 on Reader Service Card

TEFLON-COATED FABRICS—A four-page illustrated folder on the properties and applications of Fluorglas Teflon-coated glass fabrics and adhesive tapes useful for insulation and other applications have been released by **Cadillac Plastic & Chemical Co., Dept. S/A, 15111 Second Ave., Detroit 3, Mich.** The fabrics add the strength of fibrous glass to Teflon, and the range of the material goes as low as —400 deg F and as high as +600 deg F.

Write in No. 430 on Reader Service Card

CIRCUIT BREAKERS—Circuit breakers are the subject of an illustrated catalog by **Mechanical Products, Inc., Dept. S/A, Jackson, Mich.** It includes data needed for designing the protection of high capacity aircraft circuits.

Write in No. 431 on Reader Service Card

GAS TEMPERATURE PROBE—A high gas temperature probe to measure the total temperature in an after-burning turbo-jet or ram-jet engine has been prepared by **Aero Research Instrument Co., Dept. S/A, 315 N. Aberdeen St., Chicago 7, Ill.**

Write in No. 432 on Reader Service Card

CONTROL SYNCHRO — A 25 page comprehensive report on techniques of control synchro and control resolver testing has been prepared by **Theta Instrument Corp., Dept. S/A, 48 Pine St., E. Paterson, N.J.** It describes test procedures and application factors in detail.

Write in No. 433 on Reader Service Card

BUTTERFLY VALVES—V-port butterfly valves for precise controls of air or gas are discussed in specification sheet RM-100 by **Hagan Chemicals & Controls, Inc., Dept. S/A, Box 1346, Pittsburgh 30, Pa.** They are of the rotating vane type for blast furnace and coke oven gas applications.

Write in No. 434 on Reader Service Card

PNEUMATIC FUSE—Data on a pneumatic fuse covers the performance specifications and has been issued by **Aerodyne Controls Corp., Dept. S/A, 1783 New York Ave., Huntington Sta., N.Y.**

Write in No. 435 on Reader Service Card

more on page 322

Write in No. 253 on Reader Service Card

200° F

500° F

1000° F

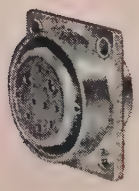
2000° F

HEAT RESISTANT...

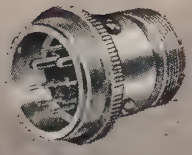
At aircraft firewalls or in guided missiles... wherever high temperatures are encountered ... you can get full protection by using Cannon Steel Shell High Temperature Connectors to protect electrical circuits.

MS-K receptacle with crimp-type contacts

FW-23 plug, either crimp or solder-pot contacts



FWR-31SL wall mount receptacle, socket insert



FWR-22 plug, pin insert assembly

Cannon Electric supplies both MS-K and FW fireproof types of electrical connectors for the protection of vital circuits in flame barrier applications.

The fireproof test of Military Specification MIL-C-5015 assures that a connector will carry a specified current for 5 minutes and prevent the passage of flame for twenty minutes while being subjected to a flame of 2000°F. Cannon MS-K Connectors meet this specification.

In addition to firewall plugs Cannon Electric has developed connectors that operate continuously up to 1000° F. Developments are under way that will increase the temperature range. We would like to suggest that you will find it well worth your while to consult our engineering personnel for full information on the newest high temperature connectors available.

For an interesting discussion of the broad subject of "Reliability," write for Cannon Bulletin R-1.

Please refer to Dept. 115

More than 27,000 Cannon Connectors assure you the opportunity of selecting exactly the right connector for any particular application you have in mind. Please write for new 44-page, 2-color Cannon Plug Guide, Bulletin CPG-3.

CANNON PLUGS

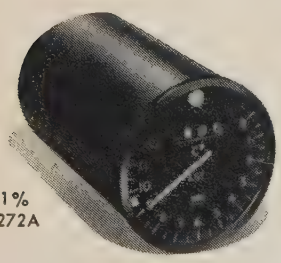
WHERE RELIABILITY IS THE 5th DIMENSION

AWARENESS OF PROBLEM · INTEGRITY OF INTENT · DESIGN EFFORT · MANUFACTURING CONTROL

CANNON ELECTRIC CO., 3208 Humboldt St., Los Angeles 31, California. Factories in Los Angeles, Salem, Mass., Toronto, Melbourne, London. Manufacturing licensees in Paris and Tokyo. Representatives and distributors in all principal cities. See your Telephone Yellow Book.

CANNON ELECTRIC

...now taking Lockheed ELECTRA'S *temperature...to 1°C.*



Accuracy 0.1%
Meets MIL-5272A

High accuracy, and easiest *needle pointer plus digital in-line counter readout,* are the principal service features of the BH183 AUTOTEMP® jet engine temperature indicator.

AUTOTEMP® is designed and produced by the makers of the JETCAL Analyzer®, the only jet engine tester used throughout the world.

The AUTOTEMP is a completely new instrument...a continuous null balance 144-inch slidewire potentiometer combined with a linearizing analog-to-digital converter. Its accuracy is the simple attribute or phenomenon of its novel and basic slidewire potentiometer!

Self-contained...silicon-transistorized, miniaturized, hermetically sealed, servo-driven...the AUTOTEMP'S 3"-diameter case includes a Zener reference, power supply, amplifier, servo motor, cold junction compensation and the 144-inch slidewire and punched tape to linearize thermocouple e.m.f. for exact, counter-type digital readout. The needle pointer indicates in 50°C increments over the 0 to 1200°C full range of the unit.

Full information is contained in our Bulletin BH183 available for the asking!

B & H INSTRUMENT CO., INC.
3479 West Vickery Blvd. • Fort Worth 7, Texas

Sales-Engineering Offices:
ATLANTA, GA., COMPTON, CAL., DAYTON, OHIO., VALLEY STREAM, L.I., N.Y., WICHITA, KAN., TORONTO, ONT. *(George Kelk Ltd.)* MITCHAM, SURREY, ENGLAND *(Bryans Aeroquipment Ltd.)*

Write in No. 259 on Reader Service Card at start of Product Preview Section

DATA PREVIEW

TURRET DRILL—A six-page folder has been issued to describe the Model 1C six spindle, sensitive, hand feed turret drill made by **Burg Tool Mfg. Co., Inc., Dept. S/A, 15001 S. Figueroa St., Gardena, Calif.** The Burgmaster turret has a power indexing turret with 12 pre-selected spindle speeds from 325 to 4050 rpm and is capable preselective of precision depth control.

Write in No. 436 on Reader Service Card

SYNCHRO TRANSMITTER—A size 8 synchro transmitter line is described in data sheet 801-T4 issued by **Daystrom, Inc., Transicoil Div., Dept. S/A, Worcester Pa.** It includes dimensioned and schematic drawings, photos, and tables of electrical and mechanical specifications.

Write in No. 437 on Reader Service Card

TEMPERATURE CONTROL—A electromechanical system which automatically holds temperature liquids, air or solids within prescribed limits in aircraft, missile and related applications is described in a bulletin issued by **Airborne Accessories Corp., Dept. S/A, Hillside, N.J.** It includes photos of the units which make up the system.

Write in No. 438 on Reader Service Card

WELDING ALUMINUM—A comprehensive survey of the techniques of welding aluminum has been issued by **Air Reduction Sales Co., Dept. S/A, 150 E. 42nd St., New York 17, N.Y.** The 120-page book covers such topics as: weldability of aluminum and its alloys, definitions and technical discussions of the two welding processes, selection of the proper process for certain job applications, descriptions of manual and automatic equipment, welding power supplies, and safety practices.

Write in No. 439 on Reader Service Card

POWER CABLE—A 32-page technical summary of high-voltage rubber cable for a variety of uses has been released by **Anaconda Wire & Cable Co., Dept. S/A, 25 Broadway, New York 4, N.Y.** The booklet presents general information on Durasheath cable specifications on cable of various types and voltages, and ampacity and installation data.

Write in No. 440 on Reader Service Card

LUBRICATION—The beneficial effects of modern lubrication methods on operating costs and production have been briefly discussed in a "Report to Management," a brochure issued by **Lincoln Engineering Co., Dept. S/A, 4010 Goodfellow Blvd., Saint Louis 20, Mo.** Data on several types of lubrication systems are included.

Write in No. 441 on Reader Service Card

LOOK FOR THE DIAMONDS—SIGN OF FINISHING QUALITY

NOW—A Great New Combination for DOUBLE PROTECTION Against Corrosive Conditions on Aluminum, Magnesium or Zinc

IRIDITE®
CHROMATE CONVERSION COATINGS
and
IRILAC™
CLEAR PROTECTIVE COATINGS

Now, here's a fast, easy, economical way to almost double the protection against corrosion on your product. Simply follow up the IRIDITE process with a fast, easy application of IRILAC . . . and you've given your product extra protection for longer resistance to corrosive conditions, longer shelf or storage life, protection from handling and increased beauty for more attractive appearance and faster sales.

ON ALUMINUM

An IRIDITE-IRILAC finish will provide longer life for storm doors, windows, outdoor furniture, auto parts and accessories, tubing or wire goods. And, you have a choice of color finishes such as natural aluminum and golden yellow. Other colors may be obtained by an additional dye operation.

ON MAGNESIUM

IRILAC over an IRIDITE No. 15 finish increases corrosion protection, and provides resistance to finger printing and abrasion on all types of products, with color appearance ranging from light to dark brown.

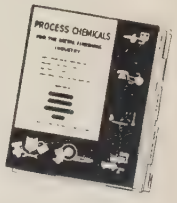
ON ZINC

IRIDITE plus IRILAC gives your product longer life and brighter appearance. Color choices range from the bright IRIDITE finish, a clear finish, through yellow iridescent to military olive drab, in addition to colored dye finishes.

IRIDITE is the tradename for a specialized line of chromate conversion coatings that can be applied to any non-ferrous metal by brush, dip or spray methods—at room temperatures—manually or with automatic equipment. Upon application, a thin film forms which becomes an integral part of the metal itself, and thus cannot chip, flake or peel. No special equipment, exhaust systems or specially trained personnel are required.

IRILAC is the tradename for a line of clear protective coatings for all metals. As safe and easy to handle as water, they may be applied by brush, dip or spray methods. No exhaust or special fire protection equipment required. Adds protection and abrasion resistance to any base metal, plated part or parts treated with electrolytic or chemical post treatments, without chemical change.

For complete technical information on IRIDITE Chromate Conversion Coatings or IRILAC Clear Protective Coatings, write for FREE TECHNICAL MANUAL. Or, see the Allied Field Engineer in your area. He's listed under "Plating Supplies" in the yellow pages.



Allied Research Products, Inc. 4004-06 EAST MONUMENT STREET • BALTIMORE 5, MARYLAND
BRANCH PLANT: 400 MIDLAND AVENUE • DETROIT 3, MICHIGAN
West Coast Licensee for Process Chemicals: L. H. Butcher Co.

Chemical and Electrochemical Processes, Anodes, Rectifiers Equipment, and Supplies for Metal Finishing

IRIDITE® Chromate Coatings	IRILAC™ Clear Coatings	ISOBRITE® Plating Brighteners	ARP® Chemicals & Supplies	WAGNER Line of Equipment

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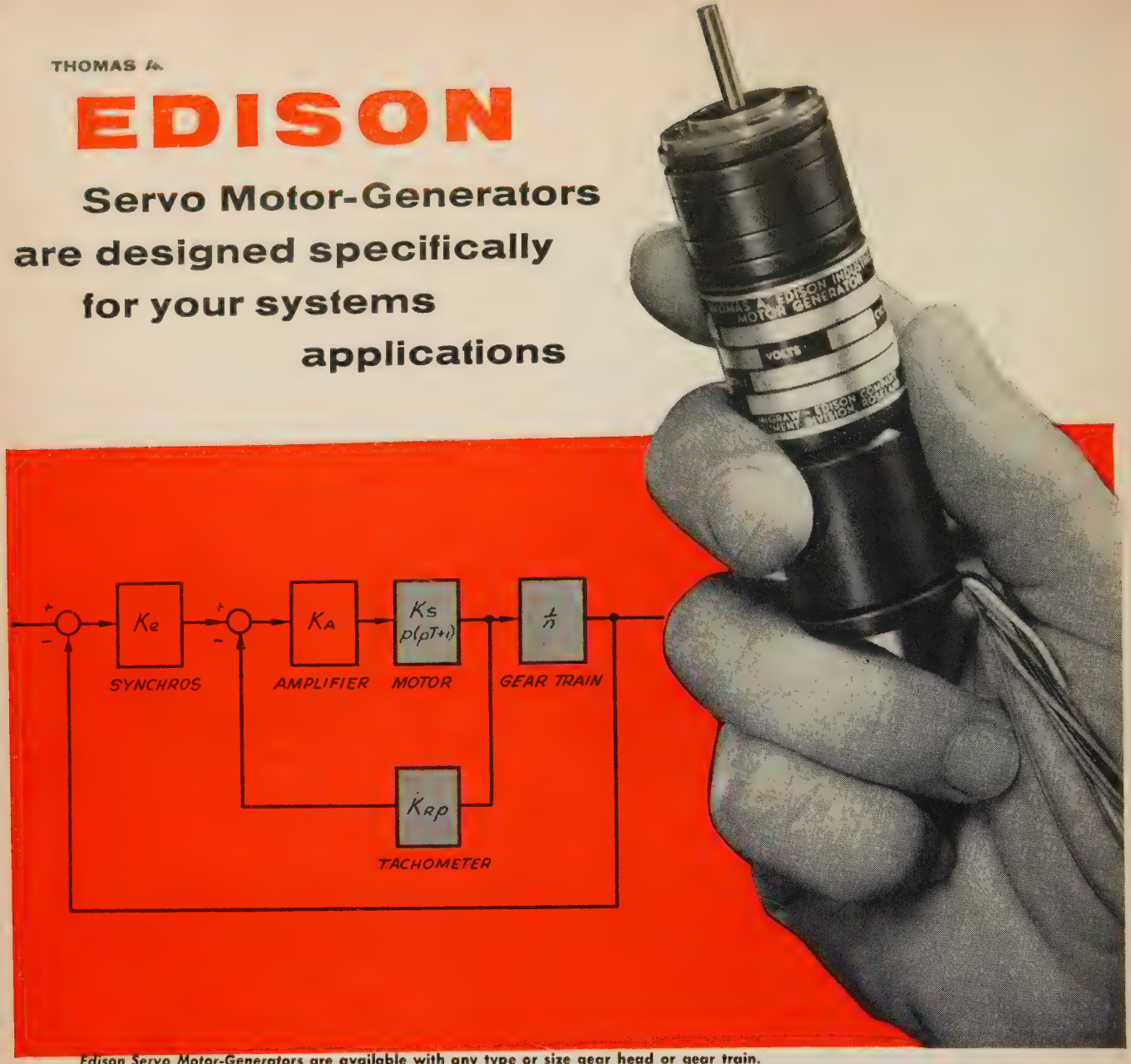
THOMAS A.

EDISON

Servo Motor-Generators are designed specifically for your systems applications



Edison Servo Motor-Generators are available with any type or size gear head or gear train.

Unlike ordinary "off-the-shelf" components, Edison Servo Motor-Generators are designed specifically to operate as part of an electro-mechanical system.

For example, their motor sections are built to have minimum time constants and reversing times. To insure precise coupling with mating gear trains, output pinions are fabricated *to better than AGMA standards.* Damping constants, from unit to unit, are held to very close tolerances.

In addition to these special system features, Edison Servo Motor-Generators are made to the highest quality standards. They outperform MIL-S-17087 (for motors) and MIL-S-17806 (for generators).

Edison engineers provide you with the exact servo motor-generator your system calls for—not a cataloged component that will only approximate your needs. For this reason, they will work closely with you in developing components that will assure you of the best system performance.

For additional information on Edison Servo Motors, Motor-Generators and other rotary components, write for Catalog 3044.

Thomas A. Edison Industries

INSTRUMENT DIVISION

48 LAKESIDE AVENUE, WEST ORANGE, N. J.

EDISON ENGINEERING OFFICES ARE LOCATED IN: CHICAGO; DALLAS; DAYTON; LOS ANGELES

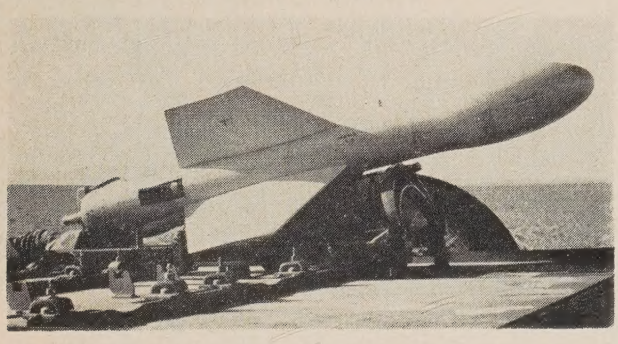
McGRAW EDISON

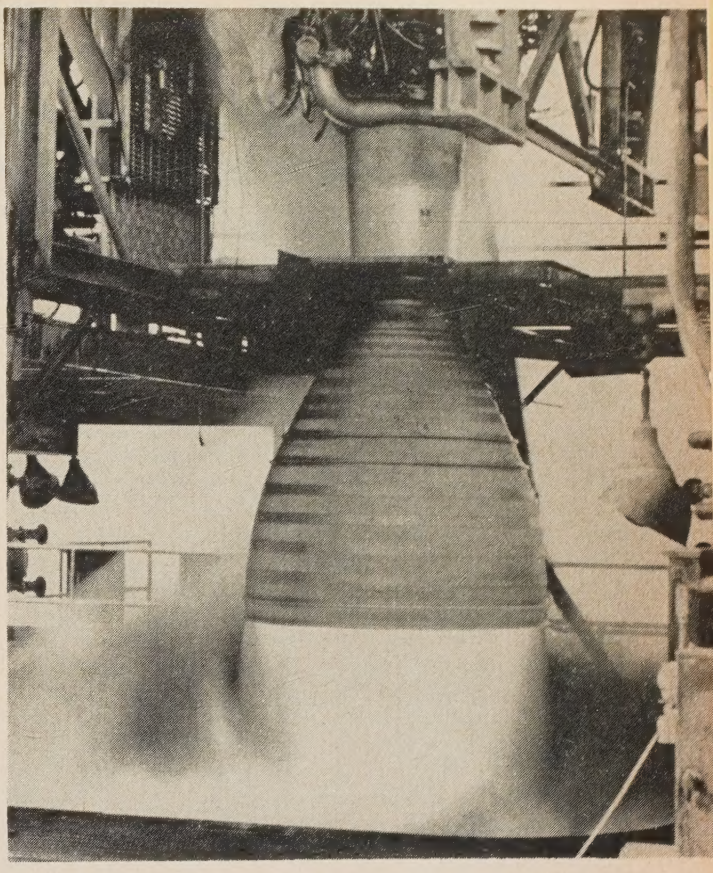
Write in No. 256 on Reader Service Card at start of Product Preview Section

JEEP AND COPTER are combined in VZ-7AP VTOL designed by Curtiss-Wright for the Army. The present flying test bed could be developed into a transport and recon craft for ground-hugging flight, says the company.

●

BIGGER BROTHER of France's highly successful Nord SS-10 and -11 missiles is the SS-12.

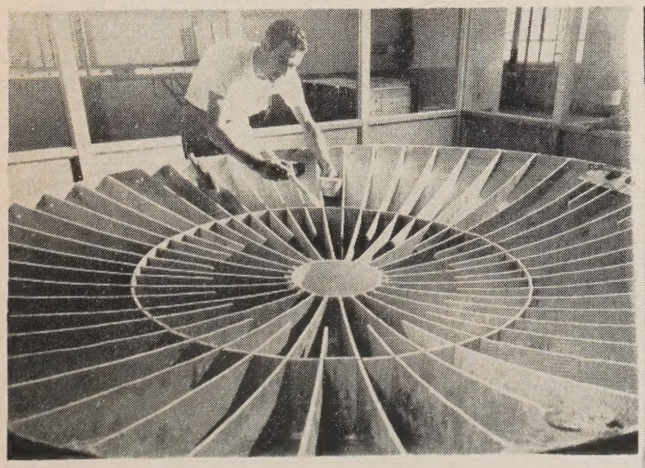


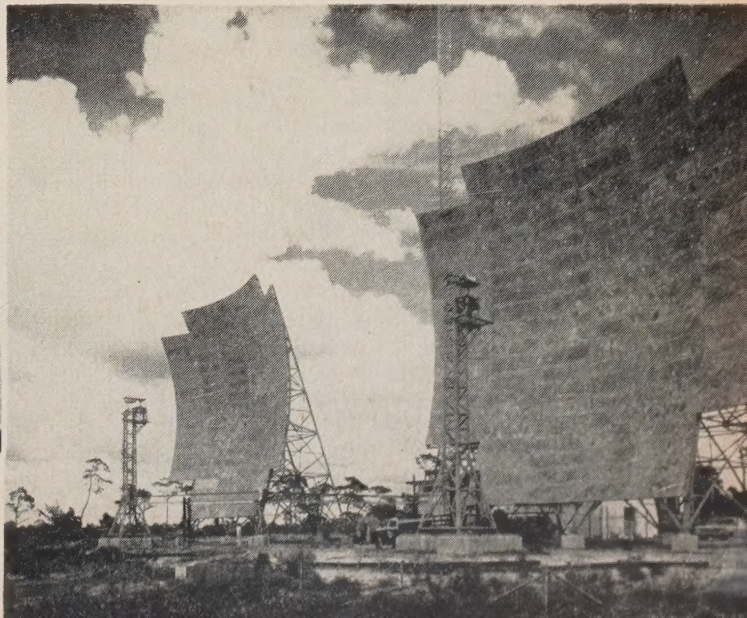


ROCKETDYNE R&D rocket, with a thrust in the 400,000-lb class, is used for studies of combustion and accessory design. It is not scheduled for any vehicle so far.

●

ANTENNA PROGRESS is shown in plastic reflector built by Republic Aviation for Tartar shipboard guidance (left) and 60 ft Blaw-Knox tropospheric scatter antennas put up at Amclote Point, Fla., for AF's Eglin Gulf Test Range. The eight-foot Tartar reflector weighs only 326 lb.





How Martin handles personnel record-keeping problems

by John F. Wallace,
Director of Employment, The Martin Co., Orlando, Fla.

THE CONSTANT SEARCH for competent personnel —especially for engineers and research men with superior qualifications—has raised a serious record-keeping problem. At Martin, we have been acutely aware of this. Recently we hired 981 people within a six-week period. Since June 1958, we have grown from 3200 to our present staff of 8000. We handle 200 new applications a day, with a total of about 15,000 currently on file.

The design and production of Bullpup, Lacrosse, Pershing, and Missile Master are the end results of the work of those 8000 employes. Of this total, 33 per cent are production workers, 25 per cent technicians, and 20 per cent graduate engineers.

In addition to the engineering and manufacturing of missiles and electronic systems, we maintain extensive research and development facilities.

Our volume of applications got so large that we couldn't process it fast enough to keep pace with the growing needs of our department heads. We were losing a great deal of time on follow-up and in searching through applications for detailed information. We lost time also in finding applications that had been removed from the files for review. This retarded our entire employment program.

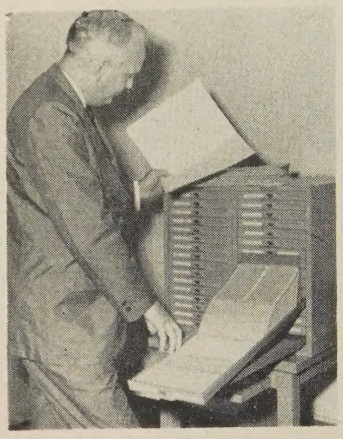
To meet these problems, a special 8x5 Remington Rand Kardex card was designed. It had spaces for all data needed for efficient and speedy follow-up (applicant's name, address, classification—one of 153—source from which we got the name, date of receipt, and purge date, which is set for six months from date of receipt).

Applicants come to us from many sources: employment agencies throughout the country, colleges and universities, display and classified ads, recommendations from within the company, and people who write, wire or come in personally.

All follow-up action is posted on the card. When a department head removes an application from the file, his name and department number and the date are inserted on the card right in the Kardex cabinet. When an application is received, this fact is noted on the card. A record of follow-up correspondence is shown by a code that indicates the type of letter sent.

Phone queries get prompt answer

Most inquiries on an applicant's status come by phone, either within the company or from outside employment agencies. The clerk never leaves her chair or the phone. With one free hand she pulls out the slide, pinpoints the name immediately on the lower visible margin, flips the card and in seconds can tell whether the applicant has called in for an interview, whether or when this was followed up, whether he has been given an offer, and whether he has rejected any offer we may have made.



EMPLOYMENT DIRECTOR John Wallace reviews an application.

She can tell at a glance the terms of an offer. If he accepted the offer, she has noted the department and section in which he is to work, the terms, the starting date, and the relocation allowance for his transfer to Orlando.

These cards are purged after six months, transferred to the inactive file and—if there is no further action after one year—destroyed. When an applicant has been hired, his card is stapled to his application form and it becomes a part of his permanent personnel records.

Six months in inactive file

When an offer has been made and we get no response after 15 days, we send our first follow-up letter. This is followed in 10 days by a second letter. If we still get no answer, the application goes into the inactive file for six months. After one year of inactivity, it is destroyed.

Before using this system, we had no real record of the routing of applications. Now a flip of a card lets us find the papers in a matter of seconds.

Our previous procedure wasted time not only when we had to get an application from the file but also because we had to search through the file to extract the request-information. Now, with all follow-up data on the card, the clerk has the answer for the inquirer within seconds. Reference is much faster and far more efficient today, which means we can process more applications in less time.

Contributions to this department may be on any subject, technical or nontechnical, about which readers would like to air their views. Names and professional affiliations will be withheld on request.

One of a series of advertisements depicting historic incidents in military communications through the ages.

GLOBAL COMMUNICATIONS—1815

The Battle of New Orleans on January 8, 1815 was fought 15 days after the end of the War of 1812. The Treaty of Ghent terminating the war between the U. S. and Britain had been signed in Europe on December 24, 1814. Yet before the news reached America, General Andrew Jackson with his motley forces of frontier militiamen, gulf pirates and a few regulars, out-numbered two to one, fought and won the memorable victory over Sir Edward Pakenham's crack line regiments—veterans fresh from victory over Napoleon. This war was but a facet of the larger global foment stirred up by the ambitions of Napoleon and the French Revolution.

The Bettmann Archive

Now, the United States is leading the free nations in building a bulwark of defense to maintain world peace in the face of today's aggressive ambitions. In this age of global commitments our defense network requires instantaneous Electronic Communications. Within seconds, policy makers and commanders must have knowledge of events, must receive and give orders. Two-way command and data-link communication, instantly available, is essential for world-wide action in time of crisis.

ECI is proud to be supplying major communications equipment to our armed forces...in surface, air-borne and space applications. Systems such as the air-borne communication and data units linking the latest USAF all-weather Century Series Interceptors into the Continental Defense network are ECI products.

ELECTRONIC COMMUNICATIONS INC. St. Petersburg, Florida

Specialists in advanced electronic communications, countermeasures, and detection systems

Regional Offices: Washington, D.C., North Hollywood, Calif., Teterboro, N.J., Dayton, Ohio, Dallas, Texas

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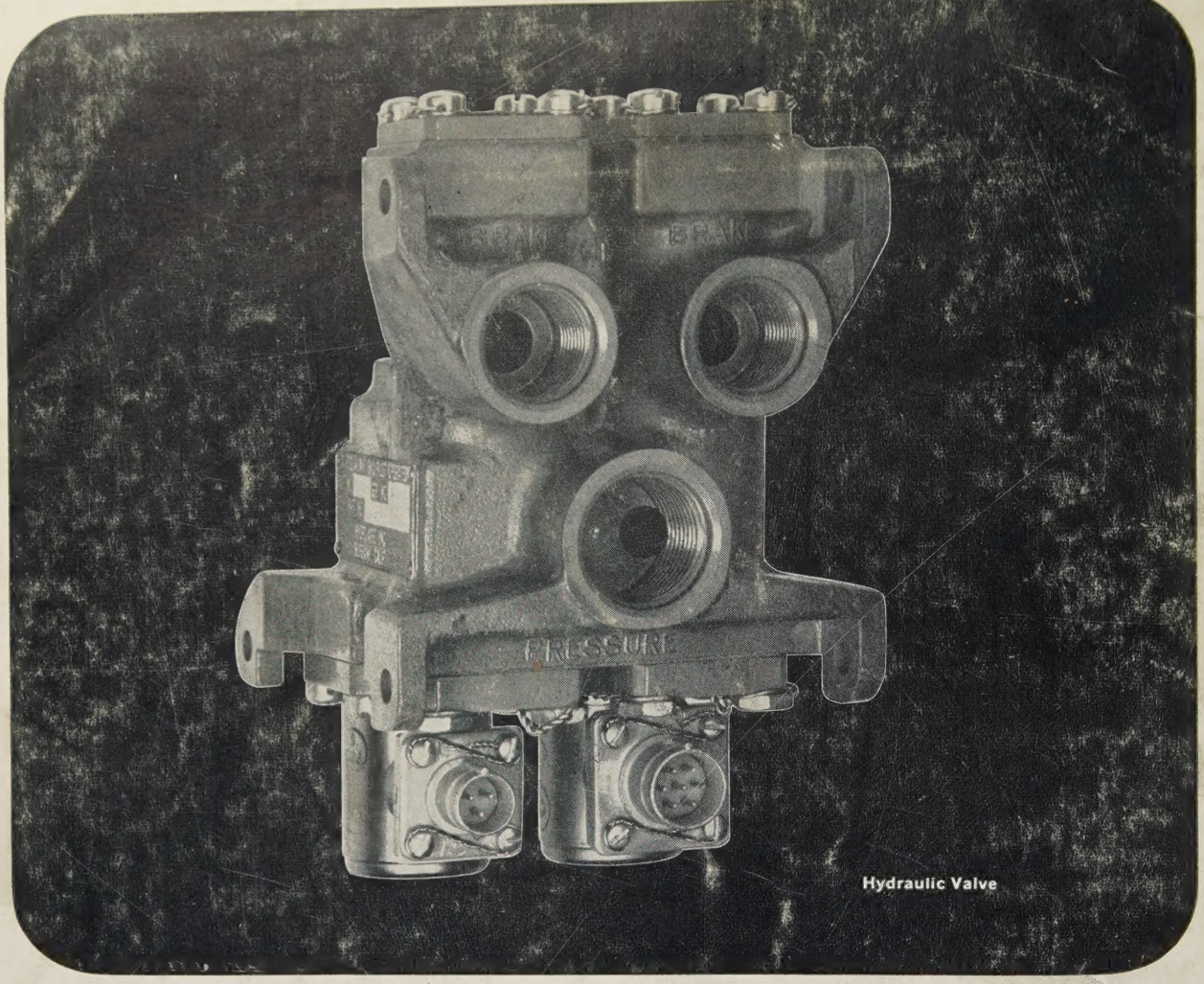
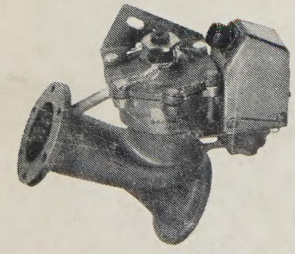
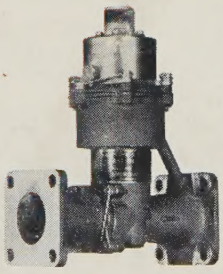


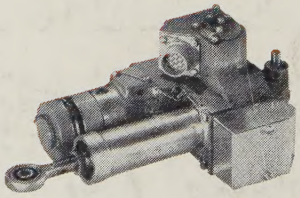
Another dependable valve from Hydro-Aire... now airborne on the "DC-8" and "880"



High Temperature Regulator and Shutoff Valve



Pneumatic Operated Gate Valve



Linear Actuator

Fuel Booster Pump

The hydraulic valve shown above is now in use on the "DC-8" and "880" in Hytrol's anti-skid braking systems with "Skydrol 500" fluid at 3000 psi. A dual pilot operated 3-way, 2 position, D.C. solenoid controlled valve, 38-131A, incorporates two separate valves (identical in design) in one housing with a common pressure and return port, and two separate cylinder ports. The operating ambient temperature range is −65°F to +200°F. The inlet flow rate is 20 GPM. Write for further details on this and other reliable products illustrated to:

HYDRO-AIRE
BURBANK, CALIFORNIA
Division of CRANE CO.
Anti-Skid Braking Systems • Fuel System Controls • Pneumatic Controls • Hydraulic Controls Actuation Systems • Electronic Devices

Producing Controls for Every Basic Airborne System

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